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THE QUARTERLY REVIEW of BIOLOGY



AMMONIUM IN THE NUTRITION OF HIGHER GREEN PLANTS

By JOSE H. PARDO

Botanical contribution from the Johns Hopkins University, No. 119

I. INTRODUCTION

POSSIBLE sources of nitrogen for the metabolism of higher plants are nitrates, nitrites, ammonium compounds and a great variety of organic nitrogen compounds, such as amino acids and amides. Some of these are commonly taken up from the soil solution, like water and the salts that do not supply nitrogen, while some are usually not absorbed as such but are formed within the plant from simpler compounds previously absorbed. It has been suggested (85) that some seed plants, such as wheat, may actually assimilate small amounts of molecular nitrogen but most physiologists and agricultural chemists consider nitrification as probably confined to lower forms such as the nitrifying bacteria of the soil and the nodule-forming symbionts.

Although there is some evidence (99, 115, 154) that nitrites may be absorbed and assimilated by higher plants, yet it has not been shown that these compounds are commonly utilized directly, indeed they are usually omitted when nitrogen sources for higher plants are considered.

While there is no doubt that some ammonia (NH_3) may enter the plant through leaves or roots, from the surrounding air or from the soil, yet only a very small portion of the nitrogen required can generally be thus absorbed, and it is difficult to consider NH_3 as actually entering living cells, for it appears to react with water to give the NH_4 ion. Harvey states (54, p. 68), however, that this gas, applied through the leaves, is "much more toxic than it should be from the alkaline reaction it produces in the cell," resulting in "the overgrowth of tissues into hyperplasias if the concentration is very low." This observation raises questions that are clearly worthy of special study. Specific effects produced by foliar absorption of NH_3 may be related to some ions other than NH_4^+ itself, or to some other special conditions accompanying the presence of NH_4^+ when due to leaf absorption of NH_3 rather than to root absorption of ammonium salts.

Root absorption of amino acids and other organic nitrogen compounds has been reported (81) by some experimenters, and such compounds are probably ab-

sorbed through leaves, haustoria, etc., in some special forms like insectivorous plants and parasites, but these compounds do not generally appear to be a significant external source of metabolic nitrogen for higher green plants. Salts of ammonium with organic acids should also be mentioned as possibly absorbed from the soil in some instances, but they seem to be of minor general importance.

It seems to be well established, however, that nitrate nitrogen is generally acceptable to all higher plants and that ammoniacal nitrogen is also acceptable under suitable conditions, at least, to many forms. Both of these sources of nitrogen are commonly present in the soil solution and in the waters of lakes and streams, but naturally their concentrations are usually relatively low. Nitrates are readily leached from soils and they are apt to be reduced to nitrites or even to ammonium salts through the action of microorganisms when conditions are suitable. On the other hand, ammonium salts, although they appear to be held in the soil to a greater extent than nitrates (68), are subject to alteration by soil bacteria, being thus oxidized to produce nitrites or nitrates. Soil bacteria may also transform a nitrite into a nitrate or into an ammonium salt, such as $(\text{NH}_4)_2\text{CO}_3$. Furthermore, the possibility that roots may sometimes exert an oxidizing or a reducing influence upon nitrogenous substances in the surrounding solution has not been excluded. It is therefore difficult to show clearly by simple experiments just what nitrogen compounds are actually absorbed by plant roots, even when it is possible to exclude nitrifying and denitrifying bacteria from some of the experimental cultures, and it is not easy to be sure that these bacteria have been excluded.

Nevertheless, experimental comparisons

may be easily made with reference to the effects produced on growth and development by different nitrogen compounds when added to soils or sand cultures or when incorporated into culture solutions, and a great deal of experimentation has been devoted to such comparisons. From this kind of experimentation, taking account of the common possibilities of nitrification and denitrification, present agricultural theory with regard to nitrogen fertilizers has been developed.

Boussingault (18) seems to have been the first to show that nitrates are a very satisfactory source of metabolic nitrogen for many green flowering plants. He discovered the occurrence of nitrification in the soil, by which process ammonium salts and nitrites become oxidized to form nitrates; numerous investigators have subsequently studied nitrification in culture media. As soon as this process became appreciated most physiologists and soil chemists argued that the absorption and assimilation of ammonium salts was at least problematic, since these might be converted into nitrates, which, in turn, would be absorbed and assimilated.

Schattenmann's (138) field experiments with sulphate, chloride and phosphate of ammonium, which were referred to by Dumas (29), are interesting historically, as at least among the very earliest published evidences of the important rôle played by ammonia in bringing about the beneficial fertilizer effects obtained from the field use of stable manure. Of course these did not touch on the question whether ammonium salts are directly assimilated or are first converted into some other nitrogen compound, but they showed that the application of these salts to the soil led to markedly improved growth and larger crops in many instances. Schattenmann noted that alfalfa and clover failed to respond to this fertilizer treat-

ment. Dumas stated that Schattenmann had discovered this "rôle de l'ammoniaque dans la végétation" before 1835, whereas Liebig's statement (84) on that topic appeared only in 1840, in which year Dumas himself had expressed the same ideas, derived in part from a personal letter received by him from Schattenmann in 1836.

By the end of the nineteenth century students of plant nutrition generally agreed that ordinary green plants (with roots in soil or solution and stems and leaves in air) derive practically all of their assimilated nitrogen from the soil, either from salts of nitric acid (the NO_3 ion) or from ammonium compounds (the NH_4 ion). In Ewart's English translation of Pfeffer's *Plant Physiology*, which appeared about the beginning of the present century and which may be taken as fairly representative of the status of plant physiological knowledge at that time, it is stated (116, vol. I, p. 392) that green plants growing on well aerated soils (i.e., soils with considerable water content, but not nearly saturated with water) usually prefer their nitrogen in the form of nitrates. Other more specific statements from the same publication are as follows:

"Most Phanerogamic plants grow best when supplied with nitrates, but ammonium salts are more suitable for others. . . ." (*ibid.*, p. 403). "In Phanerogams ammonium salts are always assimilated when present, however abundant nitrates may be" (*ibid.*, p. 404). "Neither Phanerogams nor Algae appear to have the power of forming nitrates from ammonium salts by oxidation. . . ." (*ibid.*, p. 405).

Preference of swamp rice, notably when young, for ammonium salts rather than nitrates is especially mentioned (*ibid.*, p. 404) and it is added that "this is probably often the case in plants which grow in swampy or badly aerated soil, where the process of nitrification takes place slowly

or not at all." It is pointed out, further, that "under natural conditions Phanerogams rarely absorb organic nitrogen compounds . . ." although such substances as urea, glycocoll, asparagin, leucin, tyrosin, hippuric acid, etc., may be absorbed and utilized as sources of nitrogen by flowering plants as well as algae under some conditions.

II. RECENT TEXT-BOOKS, HANDBOOKS AND GENERAL DISCUSSIONS

Authors of text-books and handbooks that have appeared in the last three decades appear to be in general agreement on the point that nitrates are generally utilized by ordinary green plants, but the question whether ammoniacal nitrogen may be commonly or only occasionally utilized by such forms seems to have remained generally about as Pfeffer left it. This question is specially difficult on account of the possibility that an ammonium salt, in an experimental soil solution or in a liquid medium as well as in ordinary field soils, may undergo oxidation with the result that the ammonium ion may seem to be absorbed and assimilated by the plants of an experiment even if nitrogen assimilation may actually be wholly or partially dependent on the absorption of the nitrate ion. The difficulty is further augmented by the logical possibility that—in some kinds of experiments at least—the ammonium ion may perhaps be absorbed to a considerable extent without being actually assimilated.

Most text-book writers agree that, while nitrates are generally more suitable for the nitrogen nutrition of higher plants, yet ammonium salts, other than the nitrate, are also assimilable, at least by many forms. One gets this idea from the books of Barton-Wright (10), Benecke and Jost (12), Green (43), Harvey (54), James (65), Jost (66), Nathansohn (104), Peirce

(112), Russell (135), Thatcher (149) and Torrey (152). In the American edition of Palladin's *Plant Physiology* (107) it is stated that "nitrates act chiefly, if not exclusively, as the source of nitrogen for higher plants," but at the same time references are given to some experiments that seem to indicate the direct utilization of ammoniacal nitrogen by some of these plants. Other writers consider that nitrates and ammonium salts are about equally suitable for the nutrition of higher plants in general; for example, Euler (36), Kostychev (76), and Maximov (91). The last-named author says (91, p. 54) that "they cannot be considered a more inferior source of nitrogen for plants than the nitrates."

Some writers of text books appear to doubt the general assimilability of ammoniacal nitrogen by higher plants. Raber (133, p. 77) says that ammonium salts are "of doubtful value in the direct nutrition of plants." Nathansohn (104), Peirce (112) and Leclerc du Sablon (136) appear to regard the question of ammonium assimilation as of minor importance, since ammonium salts are apt to be oxidized to nitrates in the soil. From the purely practical or technological viewpoint this may be a satisfactory view (since any soil may be supposed to contain nitrifying organisms as long as their absence has not been actually shown, which might in many cases be difficult in the field), but there seems to be no reason to doubt that the ammonium ion from ammonium salts may sometimes be a very important source of nitrogen, especially when the supply of nitrates is too limited. Hall appears to be inconsistent when he writes, in two books published in the same year, that "the higher plants doubtless take in the nitrogen they require as ammonia" (46, p. 221), and that "if ammonium salts are to feed the plants, they must be nitrified" (47, p. 67).

Still other authors of books on plant physiology seem to avoid the question of the direct assimilation of the ammonium ion by limiting their statements to the question of its absorption. In this group are Clements (21), Detmer (27), Duggar (30), Honcamp (58), Lepeschkin (83), Lyon, Fippin and Buckman (89), and MacDougal (90). Still others, such as Atkins (7), Barnes (22), Darwin and Acton (25), Ganong (39), Kolkwitz (73) and Timiriacheff (151), appear to leave the question of ammoniacal absorption and assimilation out of account altogether.

That plant forms seem to differ with respect to their ability to absorb or to absorb and assimilate ammonium salts and with respect to their "preference" for ammoniacal or nitrate nitrogen, was clearly stated by Pfeffer, as mentioned above, and similar statements are found in the more recent books of Linsbauer and Linsbauer (86), Lyon, Fippin and Buckman (89), Haas and Hill (45), and Jost (66). On this topic Miller's very recent book states (100, p. 503) that "the evidence indicates that some plants grow equally well with both nitrates and ammonium salts and that others, although assimilating ammonium nitrogen in the absence of nitrates, seem to prefer nitrates." Some of these differences may perhaps be related to the so-called "physiological acidity" of some ammonium salts when added to soil in which plants are grown. Thus Kostychev (76, p. 116) observes that "ammonia is nearly as good a source of nitrogen for seed-plants as nitrates whenever the plants can tolerate the resultant acid soil reaction or when the soil constituents at once neutralize the acids that are formed." On the other hand, there seems to be no reason to suspect that absorption of nitrate nitrogen may ever produce harmful effects through lowering of the H-ion concentration of the medium. It is commonly supposed that

plants differ with respect to their tolerance towards soil acidity and that such differences may explain some of their differences with respect to apparent nitrogen preferences. Several writers mention that plants seem to tolerate higher concentrations of the NO_3 ion than of the NH_4 ion. This point is clearly indicated by Euler (36), Jost (66) and Maximov (91).

Czapek (23, p. 307 *et seq.*) gives an account of the status of this problem of nitrogen nutrition about 1924, with a number of references to original contributions.

A valuable brief general discussion of the problem of the assimilation of the NH_4 ion by ordinary plants is to be found in Hutchinson and Miller's paper (63), which is accompanied by a bibliography of contributions that appeared before 1909. In their conclusion we read: "Some plants grow equally well with ammonium salt or nitrate as source of nitrogen. Other plants, while assimilating ammoniacal nitrogen in the absence of nitrates, appear to prefer nitrates. It is less certain whether ammonium salts can ever produce better final results than nitrates although we have indications that this may be the case." A brief discussion concerning what kinds of nitrogen compounds may supply nitrogen to plants was recently presented by Allison (2), who wrote:

"No doubt nitrate nitrogen is the best source of nitrogen for the majority of plants and, under conditions where nitrates are present in relatively high percentages or where the conditions for rapid nitrification are favorable, it is safe to say that most of the nitrogen assimilated is in this form." "Nitrites may also be utilized by higher plants where the concentrations are low but they are so rapidly oxidized to nitrates that they ordinarily occur only in traces in soils and there is little reason for believing that plants secure much of their nitrogen in this form." "The writer has merely taken for granted that under average field conditions nitrate nitrogen is probably the most important nitrogen source for crops, but has pointed out that other forms may also be utilized to a greater extent than has generally been supposed."

Another representative general statement about the relative nutritional values of NH_4 and NO_3 may be found in Hoagland's recent paper (55, p. 628). He says that the H-ion concentration of the medium is very important when NH_4 is the source of nitrogen," the rate of absorption of nitrogen increasing with increase of p_{H} ." He also points out that ammonium salts are more apt to be injurious to plants than are nitrates, unless various non-nitrogen culture conditions—including temperature and illumination as well as H-ion concentration—are carefully adjusted. Although NH_4 may be quite suitable as nitrogen source under properly adjusted conditions, yet "there is, in general, a greater range of safety in the use of nitrate nitrogen for the majority of agricultural plants studied."

Pirschle (119) wrote that both NO_3 and NH_4 are generally assimilated by higher plants, but that NO_3 may be superior to NH_4 , especially when the medium is poorly buffered. In the same paper Pirschle presents an interesting brief review of the manner in which theory has altered in the last three decades. That review may be summarized as follows. In the last century it was at first held, following Köhlmann and Liebig, that NH_4 was the only nitrogen source for higher plants. When NO_3 was supplied it was supposed to be reduced to NH_4 in the soil, before being absorbed by roots. Boussingault's practical experiments (18) led to the opposite idea and then NO_3 was considered as the only—or at least the best—nitrogen source for higher plants. Through the work of many investigators it is now generally thought that both NH_4 and NO_3 may be assimilated by higher plants, but it is pointed out that they do not operate alike.

Ammonium salts are said to be "physiologically acid," while nitrates are physiologically neutral or alkaline. This

distinction was first explained, following Ad. Mayer (93), by supposing that NH_4 is absorbed more rapidly than SO_4 (when $(\text{NH}_4)_2\text{SO}_4$ is supplied, for instance), thus increasing the concentration of SO_4 and of the hydrogen ion in the medium. The increasing acidity was regarded as acting toxically on many plant forms and consequently NH_4 appears to be a very poor source of nitrogen for such forms. On the other hand, when NaNO_3 is supplied it was supposed that NO_3 is absorbed more rapidly than Na, with consequent *decrease* in the hydrogen-ion concentration of the medium, but that decrease may be hindered or prevented by extrusion of anions from the roots. Prianischnikow (128) and others went on to show, however, that $(\text{NH}_4)_2\text{SO}_4$ may be as good as NaNO_3 , or even better, if acidification by the use of the former is prevented. Thus theory tended to revert to the older view of Liebig, but with the important difference that Liebig thought of reduction of NO_3 to NH_4 as occurring in the medium before absorption, while Prianischnikow thought that the NO_3 absorbed is reduced to NH_4 within the plant, as the first step leading toward the formation of amino-acids. There is much reason for supposing that NH_4 is actually the main internal source of nitrogen in amino-acid formation and if that is true it seems to follow that an ammonium salt should be superior to nitrates as external source of nitrogen, for plants that cannot tolerate high hydrogen-ion concentration in the medium, if and when the effect of physiological acidity is counteracted.

Recent studies on agricultural soils have led to further development of the theory of the physiological acidity of ammonium salts. A review of this advance was presented by Pierre (118) and a brief summary thereof may be found in Russell's textbook (135, p. 228). Many students of

this question regard it as probable that nitrification in the soil, rather than selective absorption by roots, is the cause of the soil acidification that results from the use of $(\text{NH}_4)_2\text{SO}_4$ as fertilizer. According to this view, the NH_4 is first absorbed by the soil, uniting with soil anions and releasing some of the exchangeable soil bases to form sulphates with the released SO_4 . Then the resulting absorbed ammonium salts of the soil are oxidized by nitrifying organisms, to produce nitric and soil acids, which are in turn neutralized by further reaction with remaining soil bases. Thus NH_4 is first oxidized to NO_3 , which is the actual nitrogen source that is absorbed by the plants, and the increasing acidity of the soil is due to soil acids that are set free by the process of nitrification. It needs to be pointed out that this theory has been developed for soil cultures, in which exchangeable soil bases and acids are available, and that it supposes the rate of nitrification of ammonium salts in a soil to be greater than the rate at which NH_4 may be absorbed directly by the plants growing in that soil. In solution cultures in which $(\text{NH}_4)_2\text{SO}_4$ is the source of nitrogen increased acidity of the medium may be due apparently to either nitrification or to differential absorption. The equation for nitrification may be: $(\text{NH}_4)_2\text{SO}_4 + \text{O}_2 \rightarrow (\text{nitrification}) \rightarrow 2\text{HNO}_3 + \text{H}_2\text{SO}_4 + 2\text{H}_2\text{O}$. The medium would thus become more acid without reference to absorption by the plants. On the theory of differential absorption NH_4 would be absorbed by the roots, leaving an excess of SO_4 to produce increased acidity in the medium.

The theory concerning utilization of NH_4 and NO_3 by higher green plants has been still further complicated on account of the findings of recent experimenters who have dealt with the influence of the

hydrogen-ion concentration of the medium on the suitability of these nitrogen sources for higher plants. Pirschle has dealt with this phase of the problem in several contributions and Mevius (97) has given it special attention. The last-named author has published extensive bibliographies (97, 98). Some of these H-ion relations will receive mention in the following section of the present paper. All that can be said about them in a brief general summary is that modern experimentation on the relative suitability of NH_4 and NO_3 as nitrogen sources involves careful attention to the H-ion concentration of the medium. General agreement as to these relations has not yet been obtained; different kinds of plants appear to behave differently and many other non-nitrogen conditions are apparently important in determining whether NH_4 may equal or may even exceed NO_3 in suitability.

It is not the writer's purpose to attempt here a critical review of the theoretical aspect of this problem; no clear picture of its present status is possible without an appreciation of the numerous experimental results that have been reported. Since these are not generally satisfactorily comparable (doubtless largely because of the employment of many different plant forms and many experimental techniques), the writer was led to the preparation of a sort of annotated bibliography of them and a portion of that bibliography is presented below.

III. REPORTS ON EXPERIMENTS

The numerous research articles bearing on the question of NH_4 *versus* NO_3 in the nitrogen nutrition of higher green plants are widely scattered. The present article represents a portion of the results of an attempt to summarize this part of the physiological literature. Attention is

here confined to evidence based on growth, development, configuration, general appearance and yield. The writer hopes to present subsequently a review of the literature on studies carried out from the standpoint of physiological chemistry, employing quantitative analyses of the plant material and referring to rates of absorption and to the process of assimilation itself. In many cases both of these points of view are considered in the same published contribution, but it seems advantageous to treat them separately.

Only solution-culture experiments (including sand cultures to which solutions are added) are generally considered in this review. Practical field tests of nitrogenous fertilizers, which have been carried out in great number by many workers, are not generally referred to, since such experiments inevitably involve a much larger group of unknown influences or conditions than need to be considered when physiological cultures are employed, with which much more satisfactory controls are possible. Soil cultures and field tests pertain to agriculture or ecology rather than to physiology. It needs repeated emphasis that the solutions of practical problems in agronomy and horticulture are to be sought through actual field tests, while the related scientific or theoretical problems of physiology may be approached directly only through experimental use of well-controlled solution cultures. What may be the best nitrogen fertilizers in field practice or in soil cultures, with various soils and climatic complexes and with various methods of cultivation and rotation, is a technological question, for the answering of which fundamental physiological theory is not so important as actual field experience.

In this review nitrates are generally taken as basis for comparison, in attempt-

ing to estimate, as well as possible, the efficiency of ammonium compounds. There appears to be no record of any unequivocal tests in which NO_3 was found to be very unsuitable for the nitrogen nutrition of any higher plant, although NO_3 has been equalled or surpassed in effectiveness by NH_4 . Our problem, for each plant form, is whether NH_4 has been found to be inferior, equal or superior to NO_3 . When the numerical data for comparable tests differ by not more than 10 per cent the results are considered as about equal.

Attention should be called to the fact that the term *ammonium salts* usually excludes the nitrate and *nitrates* excludes NH_4NO_3 . The last-named salt is of course both an ammonium salt and a nitrate. It is in a class by itself and requires special attention as such.

The contributions cited are presented in an arrangement of subsections according to the kinds of plants considered, the primary grouping being by plant families, which are arranged in alphabetical order. For each plant form the contributions are generally mentioned in chronological order. Numerical indices in parenthesis refer to the appended bibliography.

The material here presented was assembled in connection with a series of solution-culture experiments carried out by the writer on NH_4 assimilation by sugar cane, and some of the indications of those experiments are included here in the proper place. In the preparation of the manuscript of this review the writer has had the benefit of much helpful advice and criticism from Professor Burton E. Livingston, of the Laboratory of Plant Physiology of the Johns Hopkins University, where much of this work was done.

BALSAMINACEAE

An early experiment by Pirschle (119), with sand cultures, showed that garden

balsam (*Impatiens balsamina*) grew better when N was supplied as $\text{Ca}(\text{NO}_3)_2$ or KNO_3 than when $(\text{NH}_4)_2\text{SO}_4$ or NH_4Cl was the only nitrogen source.

BROMELIACEAE

Stewart, Thomas and Horner (147) made an extensive study of the nitrogen nutrition of pineapple (*Ananas sativa*) in Hawaii and concluded that "under field conditions the pineapple plant probably uses nitrogen in both the nitrate and ammonium forms." Their experiments showed better growth with NO_3 than with NH_4 when the N content of the nutrient solution was 160 mg. per liter, but yields from NO_3 and from NH_4 were about alike when the N content of the solution was only 40 mg. per liter. They noted that the "crown" (the top cut off from the familiar pineapple fruit) was preferable to "slips" or "suckers" in culture experiments.

CHENOPODIACEAE

Pitsch (123), using potted plants of sugar beet (*Beta vulgaris*) in sterilized soil, found that NO_3 was preferable to NH_4 with regard to root production but NH_4 sometimes gave higher sugar contents. Dikussar's experiments with sugar beet (28) gave highest weight yields with NO_3 when the nutrient medium had a p_{H} value of 5.5, but NH_4 gave better growth than was given by NO_3 when the medium was neutral.

Krüger's experiments (79) with mangel were inconclusive as to this plant's response to NO_3 and NH_4 ; in one test NH_4 gave greater root yield than was given by NO_3 but two other tests showed NO_3 to be superior. Krüger employed both sterilized and unsterilized media.

Strawberry Blite (*Chenopodium capitatum*) was found by Pirschle (121) to grow better with N supplied as NO_3 than when the nitrogen source was NH_4 , for

several different H-ion concentrations of the medium.

COMMELINACEAE

Wandering Jew (*Tradescantia fluminensis*) was included in the experimentation of Mevius (97), whose data indicate that NO_3 was superior to NH_4 in the nitrogen nutrition of this plant. But $(\text{NH}_4)_2\text{SO}_4$ gave fair growth in some experiments. Pirschle (119, 120, 121) also found, for a series of different p_{H} values of the nutrient solution and with continuously flowing as well as with unrenewed solutions, that NO_3 gave better growth of *Tradescantia viridis* and *Zebrina pendula* than was given by NH_4 . Later continuous-flow experiments by the same writer (122) showed that NH_4 was superior to NO_3 for *T. viridis*; the optimal yield was obtained with NH_4 and a p_{H} value of 7.0.

COMPOSITAE

Perotti (114) included sunflower (*Helianthus annuus*) in the experimental series by which he came to the somewhat broad conclusion that flowering plants were able to derive their needed nitrogen directly from $\text{Ca}(\text{CN})_2$. In Pirschle's tests (120, 121) sunflower gave larger yields with NO_3 as nitrogen source than when N was supplied as NH_4 , but NH_4 appeared to be superior to NO_3 when the medium had a p_{H} value of 6.0.

CRUCIFERAE

In one of Krüger's tests (79) mustard (*Sinapis*) grew as well with NH_4 as with NO_3 , but another test showed NO_3 to be superior. In Pantanelli and Severini's experiments (108, 109) mustard grew better with N supplied as ammonium tartrate or NH_4NO_3 than when it was supplied as NaNO_3 , but the latter was superior to NH_4Cl or $(\text{NH}_4)_2\text{SO}_4$. Pirschle (119, 121) found, with both continuously flowing

and unrenewed solutions, that NO_3 was superior to NH_4 for mustard, with a range of p_{H} values from 3.0 to 9.0. Another experiment (122) showed these two sources of N to be of about the same effectiveness.

Pirschle's experiments (119, 120, 121) gave results with rape (*Brassica rapa*) similar to those first obtained by him with mustard. In another experiment, with continuously flowing solutions, the greatest yields were about alike for NO_3 and NH_4 , but NH_4 was superior when the p_{H} value of the solution was 5.0. The two nitrogen sources were about alike for a p_{H} value of 6.0 and NO_3 was superior for p_{H} values of 4.0, 7.0, 8.0 and 9.0. When both NO_3 and NH_4 were supplied together (as NH_4NO_3) the optimal yields (with p_{H} value of 5.0, 6.0 or 7.0) surpassed the best yields obtained with NO_3 as the only source of N. This combination gave results like those obtained with NO_3 , when the solution had a p_{H} value of 4.0 or 8.0, and it was inferior to NO_3 with a p_{H} value of 9.0. Pirschle obtained very good growth of rape in flowing solution cultures with urea as the only source of N.

CUCURBITACEAE

Perotti's (114) results with pumpkin (*Cucurbita pepo*) were better with NO_3 than with NH_4 , and the same is true of Pirschle's (119, 120, 121) tests of this plant, for a wide range of H-ion concentrations of the medium. On the other hand, Tiedjens and Robbins (150) grew cucumber to excellent fruiting in sand cultures in which N was supplied only as $(\text{NH}_4)_2\text{SO}_4$, in a solution having a p_{H} value of 7.5. Number and quality of fruits, as well as general growth, were as good as in commercial greenhouse culture. The photograph shown by these authors (their figure 8) is remarkably striking. When the p_{H} value of the $(\text{NH}_4)_2\text{SO}_4$

solution used was 5.4 growth was slow and leaves were small and light green, but when the p_H value was afterwards changed to 7.5 the foliage became dark green and subsequent growth was rapid.

ERICACEAE

Addoms and Mounce (1) found that cranberry plants (*Vaccinium macrocarpon*) produced noticeably greater runner growth with $(NH_4)_2SO_4$ than with $Ca(NO_3)_2$.

EUPHORBIACEAE

Pirschle's (119, 121) experiments with castor bean (*Ricinus communis*), in continuous-flow as well as in unrenewed solution cultures, gave greater yields with NO_3 than with NH_4 , for a wide range of p_H values, but with a p_H value of 5.0 NH_4 was superior to NO_3 .

GRAMINEAE

Because of their great economic importance, several of the Gramineae have been extensively experimented upon and a large number of contributions by many writers are to receive brief attention in this section. The annotations are brought together in subsections, as follows: Barley, English rye grass, Maize, Millet, Oats, Rice, Rye, Sorghum, Sugar Cane, Wheat; and a final subsection presents an attempt to summarize the experimental results for this family.

Barley (Hordeum vulgare)

The literature on the nitrogen nutrition of barley appears to begin with a paper by Ville (159), published in 1875, in which he reported that this plant gave good growth when N was supplied as NH_4Cl , as well as when the source of N was an organic compound such as urea. Ville did not report on nitrates. Pitsch's extensive experiments (123) with several varieties of barley grown in pots of steril-

ized soil gave better growth with N supplied as $NaNO_3$ than when $(NH_4)_2SO_4$ was the source of N. Kossowitsch (74) grew this plant in sterilized sand and reached the conclusion that both NO_3 and NH_4 were assimilated when they were supplied together. Krüger (79) tested barley in pots with a mixture of soil and sand, sterilized as well as unsterilized, and obtained larger yields with NO_3 than with NH_4 in some experiments while other experiments showed these two sources of N to be about equally effective. Ehrenberg's experiments on barley (31) gave superior yields with NO_3 and he concluded, from an extensive study of the whole problem of nitrogen nutrition, that NO_3 was the only suitable source of N for higher plants in aerated soils, although NH_4 might be assimilated from wet, acid soils. The results of Aso and Bahadur (6) indicated that NO_3 and NH_4 were about equally suitable as sources of N for barley, and a similar conclusion may represent the results of sand-culture experiments by Pfeiffer, Hepner and Frank (117). The last-named writers reported even better yields from NH_4NO_3 than from either NO_3 or NH_4 alone. From Prianschnikow's results with sand cultures (125, 126) it appears that $(NH_4)_2SO_4$ gave poor growth of barley unless it was accompanied by $CaHPO_4$, in which case growth was about as good as when $Ca(NO_3)_2$, $NaNO_3$ or NH_4NO_3 was used with $CaHPO_4$. Prianschnikow's best growth of this plant occurred when $Ca(NO_3)_2$ and the phosphate were used together. Nehring (105) grew barley to maturity in unrenewed sand cultures with different H-ion concentrations, using several different compounds as nitrogen source. Judged by grain weight, optimal yields were obtained with $(NH_4)_2SO_4$ and with $Ca(NO_3)_2$, which were practically alike, while $NaNO_3$, urea, and the other

nitrogen compounds tested were sub-optimal. With a p_H value of 5, $(NH_4)_2SO_4$ and $Ca(NO_3)_2$ were equally effective, but the nitrate led to better yields with p_H values of 6 and 7 while the NH_4 salt was superior when the p_H value was 8. The best yield for $NaNO_3$ was obtained with p_H value of 5 and the best for urea was obtained with p_H value of 7. In sand cultures of barley, without washing or renewal of the solution, Pirschle (120, 121) found NH_4 inferior to NO_3 for a wide range of initial p_H values of the solution, but these two sources of N were about equally effective when the sand was subjected to frequent washing and renewal of the solution and when the p_H value of the solution was 7.0, 8.0 or 9.0. When the p_H value was below 7.0, NO_3 was superior to NH_4 , even with frequent washing and renewal of the solution.

Summarizing the results obtained with barley, no one appears to have recorded any experiments in which NH_4 was found to be definitely superior to NO_3 for the growth of barley, but NH_4 has apparently equalled NO_3 in effectiveness when the experimental conditions other than nitrogen supply were suitable. It seems that growth of barley might be retarded by relatively high acidity resulting indirectly from the use of ammonium salts in the nutrient medium and that NH_4 might not be a suitable source of N for this plant unless experimental conditions prevented the development of excessive H-ion concentration or antagonized the toxic effect of acidity in some way. Ammonium nitrate seems to have been a suitable source of N for barley in experiments in which that salt has been tested.

English rye grass (Lolium perenne)

Pirschle's tests (119) indicated that NO_3 was superior to NH_4 for the nitrogen nutrition of English rye grass.

Maize (Zea Mays)

Among the earliest experimenters on the ammonium nutrition of maize was Hampe (48, 49, 50, 51), who employed solution cultures. He found that this plant grew well with N supplied as NO_3 but concluded that NH_4 of inorganic salts was absorbed and assimilated if the harmful effects of the acidity resulting from its absorption were not allowed to become too pronounced. He found urea superior to uric acid and glycocoll as good as nitrates for his maize plants. Kühn (80) also reached the conclusion that maize could assimilate NH_4 in solution cultures. His plants grown with NO_3 as the only source of N failed to mature but those supplied only with ammonium phosphate or with $(NH_4)_2SO_4$ reached maturity. Wagner (161) reported that young maize plants did not thrive when N was supplied as ammonium phosphate. Ammonium carbonate gave poor growth but its injurious effect was much less pronounced when the culture solution was kept nearly saturated with CO_2 . He thought that glycine and creatine were absorbed and assimilated by maize. The conclusion that NH_4 was assimilated by this plant was also reached by Muntz (101), but Mazé (94, 95) thought that nitrification had occurred in Muntz's cultures supplied with NH_4 as the only source of N. However, when Mazé repeated Muntz's experiments the results were similar to those reported by the latter. Mazé came to the conclusion that NH_4 was as good as NO_3 if the N concentration were kept relatively low. He also noted that maize in advanced stages of development grew more rapidly with NO_3 than with NH_4 . Gerlach and Vögel (41) carried out what appear to have been very careful tests with sterilized-solution cultures of maize, obtaining just as good growth with NH_4 as with NO_3 . Perotti (114) also agreed

that NH_4 was directly assimilable by this plant. Lehmann (82) found that young maize plants gave better growth with NH_4 than with NO_3 but as his plants became larger and older NO_3 was superior. Direct assimilation of NH_4 by maize was confirmed by Kalinkin (67). With sterilized-sand cultures Schulow (142, 143) obtained better growth of maize with NH_4NO_3 than with $\text{Ca}(\text{NO}_3)_2$, in the presence of KH_2PO_4 , but his best results with the phosphate were secured with asparagin as source of N.—Rautenberg and Kühn (134) failed to obtain good growth of maize with NH_4 as the only source of N but NH_4NO_3 gave larger yields than were obtained with NO_3 alone. Graftiau (42) furnished additional evidence supporting the conclusion that NH_4 was directly assimilated by maize, without previous transformation. That different varieties of maize showed different relations to NO_3 and NH_4 was reported by Brigham (19); pop-corn appeared to prefer NO_3 to NH_4 but dent corn grew better with N supplied as NH_4 . With *Bacillus subtilis* in the culture medium, urea, asparagin and alanine each gave some very good yields in Brigham's maize experiments. Prianischnikow (128) obtained better growth of maize with NH_4Cl (along with CaCO_3) than with $\text{Ca}(\text{NO}_3)_2$. In another paper (131) the same writer says that Dikusar had found, for maize as well as for sugar beet, that NH_4 was superior to NO_3 when the p_{H} value of the medium was 7.0, while NO_3 was superior when the p_{H} value was 5.5. Mevius (97), using solution cultures, gave special attention to the question of the "physiological acidity" of ammonium salts and the influence of CaCO_3 , aeration, and other factors in counteracting it. In general, his largest yields of maize were obtained with NH_4NO_3 , and NH_4 alone was superior to NO_3 alone only when low concentrations were employed. Loo (87,

88), using solution cultures, obtained greater maize yields with NaNO_3 than with NH_4Cl or $(\text{NH}_4)_2\text{SO}_4$. Ammonium nitrate and $(\text{NH}_4)_2\text{HPO}_4$ gave yields as good as NaNO_3 in some tests but other tests showed them to be inferior to NaNO_3 . Allison's (2) solution cultures gave somewhat greater weight yields with $(\text{NH}_4)_2\text{SO}_4$ than with NaNO_3 but use of these two salts together gave greater yields than were obtained with $(\text{NH}_4)_2\text{SO}_4$ alone. Pirschle's (119, 120, 121, 122) solution cultures with unrenewed solutions showed NO_3 superior to NH_4 for maize. Four experiments with continuously flowing solutions showed superiority of NH_4 to NO_3 when the p_{H} value was 5.8. With p_{H} value of 5.0, 6.0, 7.0, or 7.1 yields with NO_3 and NH_4 were about alike and NO_3 was superior when the p_{H} value was below 5.0 or above 7.0. Similar results were obtained in an additional experiment with continuous flow of solution, but in this the optimal yields were obtained when both NO_3 and NH_4 were present, as NH_4NO_3 . In the acid range of p_{H} values the last-named salt gave better growth than was given by the use of NO_3 alone. In Pirschle's most recent experiment (122) the similarity of NH_4 and NO_3 was extended far into the alkaline range of p_{H} values, as far as 8.0.

Summarizing the results of culture experiments on the nitrogen nutrition of maize, good growth has been obtained in many instances when NH_4 was the only source of N and NH_4 has been found superior to NO_3 in some cases. Ammonium seems to have given about as good growth as was obtained with NO_3 when the nutrient medium was not too acid and especially when the N content of the medium was relatively low. Different varieties and different stages of development of the plants appeared to show different relations to NO_3 and NH_4 . Am-

monium nitrate, which supplies both NO_3 and NH_4 together, gave better growth than was given by either NO_3 or NH_4 alone.

Millet (Setaria)

Ehrenberg (32) reported that NO_3 was superior to NH_4 as source of N for sugar millet.

Oats (Avena sativa)

As early as 1859 Knop (71) published a report on soil-pot experiments concluding that NaNO_3 and NH_4NO_3 were equally beneficial to oats, but that urea, hippuric acid and some other organic nitrogen compounds were not suited to this plant. Birner and Lucanus (15) concluded that NO_3 could not be replaced by NH_4 for oats, and Bener (13, 14) also failed to obtain good growth of this plant with NH_4 as source of N. Pitsch (123) compared NO_3 with NH_4 in experiments with oats and found the nitrate to be decidedly superior. Clausen (20) obtained better growth of this plant with $(\text{NH}_4)_2\text{SO}_4$ than with NaNO_3 but he was inclined to attribute this result to characteristics of the soil used. Of Krüger's (79) three experiments with oats, one showed NH_4 and NO_3 to be equally effective, another showed NH_4 to be superior and a third showed NO_3 to be superior. As for barley, so also for oats, this writer considered NO_3 and NH_4 as about equally good. Ehrenberg (31) failed to obtain good growth of oats with NH_4 . While Prianschnikow (124, 130) found NH_4 inferior to NO_3 for oats, the former was apparently assimilated to some extent under some conditions; nitrate gave the best growth. From his sterilized-solution cultures Schulow (143) concluded that both NH_4 and NO_3 were suitable for oats in early growth phases but that NO_3 was a better source of N when the plants were

more advanced. Pfeiffer, Hepner and Frank (117) found NO_3 superior to NH_4 for this plant. In the sand-culture experiments of Pirschle (119, 121) optimal weight yields of oats were obtained with NO_3 , whether or not the sand was frequently washed, with renewal of the solution. In one experiment NH_4 gave some yields about as good as were obtained with NO_3 , but only with solutions having p_{H} values as high as 7.0, 8.0, or 9.0. The best yield was with NO_3 and a p_{H} value of 5.0. In Pirschle's solution cultures, with continuous flow as well as without renewal, oats grew best with NO_3 as source of N. In later experiments Pirschle (120, 122) obtained about as good growth with NH_4 as with NO_3 when the p_{H} value of the solution was 6.0.

Summarizing the results on oats, the effectiveness of NO_3 as N source appears to have been closely approached by NH_4 in only a few instances and no report has been found in which NH_4 is shown to have been superior to NO_3 for this plant. The effectiveness of NH_4 seems to have depended on the H-ion concentration of the medium, probably also on other features. Oats appears to be much like barley in this respect.

Rice (Oryza sativa)

Readers who are specially interested in rice will find Kondo and Isshiki's recent bibliography (72) a very valuable aid. The study of the nitrogen relations of this plant seems to have begun with Kellner (70), who published in 1884. From experiments with solution cultures they concluded that both NO_3 and NH_4 were assimilated by this plant, but NH_4 gave best results with young plants while older plants grew better with NO_3 as source of N. In general, their best results were obtained when both of these sources of N were supplied together, as NH_4NO_3 .

Nagaoka (103) found NH_4 superior to NO_3 , confirming a similar conclusion of Daikukara and T. Imasaki (24). Aso and Bahadur (6) agreed with Nagaoka and went so far as to regard NaNO_3 as unsuitable for rice. Pantanelli and Severini (108) found, in sterilized-solution cultures, that NaNO_3 gave better growth than was given by NH_4Cl , about as good growth as was given by NH_4NO_3 or $(\text{NH}_4)_2\text{SO}_4$, but optimal yields were obtained when they used $(\text{NH}_4)_2\text{PO}_4$ or NH_4MgPO_4 as source of N. Krauss (77, 78) concluded, from soil-pot and field tests, that ammoniacal nitrogen was specially suitable as nitrogen source for rice. Perciabosco and Rosso (115) found that rice was peculiarly sensitive to nitrite poisoning. Kelley (68, 69), working in Hawaii, wrote that $(\text{NH}_4)_2\text{SO}_4$ led to "considerable increases in yield of straw and grain of rice, while nitrate of soda was ineffective." Harrison (53) found that NO_3 was effective on rice paddies while ammonium gave good results. Trelease and Paulino (156), working at Los Baños, employed pots of solution-saturated soil and studied the salt nutrition of rice by the method of triangular diagrams, which had been introduced by Schreiner and Skinner (139, 140), Tottingham (153) and others. Best yields of straw and grain were obtained with $(\text{NH}_4)_2\text{SO}_4$ but NH_4NO_3 was nearly as effective as the sulphate. Sodium nitrate and $\text{Ca}(\text{NO}_3)_2$ gave much less satisfactory growth. Espino (33) employed solution cultures of young rice plants on a rotating table in the greenhouse of the Johns Hopkins University, at Baltimore, and used the triangular diagram in choosing sets of salt proportions that would represent a wide range of logical possibilities. His best growth was obtained with NH_4NO_3 ; when NO_3 was the only source of N growth was only fair; when the

source of N was NH_4 alone the best sets of salt proportions gave dry yields nearly as large as were obtained with NH_4NO_3 but what was taken as "ammonium injury" to the foliage was then present. Willis and Carrero (163) also held that nitrates were less suitable than ammoniacal nitrogen for rice. Loo (87, 88) compared $(\text{NH}_4)_2\text{SO}_4$, NaNO_3 , NH_4HPO_4 and NH_4NO_3 , and took the H-ion concentration of his solutions into account. In one test $(\text{NH}_4)_2\text{SO}_4$ gave largest yields and the three remaining salts gave good yields that were about alike. In another test yields from all four salts were good and nearly alike. Very poor growth was obtained with NH_4HCO_3 as source of N. Bartholomew (9) obtained better rice yields with $(\text{NH}_4)_2\text{SO}_4$ and with some organic nitrogenous fertilizers than with NaNO_3 . Palisoc (106) found, with solution cultures, that NH_4NO_3 was greatly superior to $(\text{NH}_4)_2\text{SO}_4$, while $\text{NH}_4\text{H}_2\text{PO}_4$ led to poor growth. Fukaki's (38) solution-culture experiments with rice showed $(\text{NH}_4)_2\text{SO}_4$ as better than $\text{Ca}(\text{NO}_3)_2$ for vegetative development, but these nitrogen sources were about equally effective for seed production and $\text{Ca}(\text{NO}_3)_2$ was somewhat more favorable for seed maturation. Espino and Estioko (35) found that NH_4 was superior to NO_3 for young rice plants, but they held that some NO_3 was essential to healthy foliage and concluded that both NO_3 and NH_4 were required in cultures of rice when young. Pirschle's (121) sand cultures of this plant, with frequent washing and renewal of the solution, gave optimal dry-weight yields when N was supplied as NH_4 , but NO_3 was superior to NH_4 in his cultures without renewal of solution. With regard to H-ion concentration of the medium, NH_4 was superior to NO_3 when the p_{H} value of the solution was 6.8, 7.0 or 8.0, but NH_4 was inferior when the p_{H}

value was 3.0, or 4.0. Pirschle's experiments with continuous flow of solution (122) showed as good yields with NH_4 as with NO_3 , but NH_4 was superior when the p_H value of the solution was 5.0, 6.0 or 7.0 and the yields were about alike when the solution had a p_H value of 8.0 or 9.0. The best yields of all were obtained when N was supplied as urea or when NH_4 and NO_3 were supplied together, either as separate salts or as NH_4NO_3 .

Summarizing the experimental evidence for rice, it seems safe to conclude that this plant has generally grown better with NH_4 than with NO_3 as source of N, in cultures as well as in paddy-field experiments. But some cultures gave equally good results with either NH_4 or NO_3 and in some instances NO_3 appeared to be somewhat superior to NH_4 . Rice appears to have shown less sensitiveness to "physiological acidity" than most of the other plants whose nitrogen nutrition has been experimented upon. There seems to be no doubt that this plant is able to assimilate both NO_3 and NH_4 and some writers think that both of these ions are essential to excellent growth and healthy foliage. Ammonium nitrate has given very good results with rice.

Rye (Secale cereale)

Pirschle's experiments (121) with rye showed this plant to be much like oats and barley, generally showing optimal yields with NO_3 as source of N, with similar relations to the H-ion concentration of the medium. The ammonium ion seems generally to have been unsuitable as the only source of N for this plant.

Sorghum (Holcus sorghum)

Pirschle's (121) solution cultures with unrenewed solutions showed NO_3 to be superior to NH_4 as source of N for sor-

ghum. When the solutions were renewed continuously NH_4 gave the largest weight yields with p_H value of 5.0 or 6.0, but NO_3 gave largest yields with lower or with higher p_H values. The writer of the present review has recently carried out a series of solution-culture experiments on sorghum, in the greenhouse of the Johns Hopkins Laboratory of Plant Physiology. The results of these tests, which have not yet been published, show that best growth was obtained when N was supplied as $\text{Ca}(\text{NO}_3)_2$ but NH_4NO_3 gave nearly as good growth. Fair growth was obtained with $(\text{NH}_4)_2\text{SO}_4$ as the only source of N. It appears that these sorghum plants were able to assimilate some of their required N as NH_4 but that their preference was for NO_3 .

Sugar Cane (Saccharum)

McGeorge's (96) sand-culture tests gave good growth of sugar cane with N supplied as NO_3 but not when NH_4 was the only source of N. Van den Honert (59) found that NH_4 gave poor growth of sugar cane and attributed this to a characteristic root injury, which appeared in his NH_4 cultures. He recalled that Miss G. Wilbrink had previously observed a similar root injury in cane plants that had been subjected to the influence of ammonium salts. In Pardo's (110) preliminary solution-culture tests NaNO_3 was a very effective source of N for sugar cane. Urea gave fair results but cultures with $(\text{NH}_4)_2\text{CO}_3$, with certain amino acids or with guanidine as source of N showed very poor growth. Additional experiments by the same writer (111) indicated that $(\text{NH}_4)_2\text{SO}_4$, NH_4NO_3 and urea were decidedly inferior to $\text{Ca}(\text{NO}_3)_2$ for young cane plants but that older plants (after 20 or 32 weeks of solution culture) grew better with NH_4NO_3 than with $\text{Ca}(\text{NO}_3)_2$ as source of N. Considerable experimen-

tal evidence favors the tentative conclusion that sugar cane prefers NO_3 in its earlier phases of development but that NH_4 may be superior to NO_3 when the plants are more advanced.

Wheat (Triticum sativum)

Mayer (92), who published in 1874, thought that wheat might assimilate NH_4HCO_3 when absorbed through the foliage. Ville (159) found, as with barley, that NH_4Cl and some organic nitrogen compounds gave good growth of wheat, but he did not include nitrates in his tests. Pitsch's (123) pot experiments with sterilized soil included winter and spring wheat as well as barley and oats and he obtained better growth of wheat with NaNO_3 than with $(\text{NH}_4)_2\text{SO}_4$, just as in the case of the other two cereals. However, some of his tests with winter wheat showed $(\text{NH}_4)_2\text{SO}_4$ to be nearly as effective as NaNO_3 . Pfeiffer, Hepner and Frank (117) found NaNO_3 to give better growth of wheat in sand cultures than was given by either $(\text{NH}_4)_2\text{SO}_4$ or NH_4NO_3 , the latter being somewhat the better of these two ammonium salts. Perotti (114) obtained good growth of wheat in soil cultures with NH_4NO_3 and with $\text{Ca}(\text{CN})_2$. Hutchinson and Miller (63), who used sterilized-sand cultures as well as solution cultures, found that NaNO_3 gave much better growth of this plant than was given by $(\text{NH}_4)_2\text{SO}_4$ but that when the latter salt was applied with CaCO_3 it gave about as good growth as was given by NaNO_3 . With sterilized solutions Pantanelli and Severini (108) found NaNO_3 to be a better source of N for wheat than either NH_4Cl or $(\text{NH}_4)_2\text{SO}_4$, but $(\text{NH}_4)_3\text{PO}_4$ or NH_4MgPO_4 led to yields several times as large as were obtained with NaNO_3 . In sterilized-sand cultures these same authors (109) found that KNO_3 gave better results than were

obtained with either $(\text{NH}_4)_3\text{PO}_4$ or NH_4MgPO_4 . Several organic salts of NH_4 were also tried, as well as phosphates. These writers concluded that the injurious influence of NH_4 salts of strong acids might be avoided through the use of NH_4 salts of weak acids. Loo's (87, 88) solution cultures of this plant gave about as good growth with NH_4HPO_4 as with NaNO_3 , perhaps because the phosphate did not give rise to such high H-ion concentration as is apt to result from the use of $(\text{NH}_4)_2\text{SO}_4$ or NH_4Cl . Pirschle (119, 121) included wheat in his sand-culture experiments, with and without frequent washing and renewal of the solution, and found NH_4 and NO_3 about equally good when the p_H value of the solution was 3.0, 7.0 or 9.0; when the p_H value was 6.0 or 8.0, however, NH_4 led to the better growth and when the p_H value was 4.0 or 5.0, NH_4 was inferior to NO_3 . In solution cultures, with continuous flow as well as with unrenewed solutions, Pirschle obtained better growth of wheat with NO_3 than with NH_4 . Further experiments (120, 122) gave nearly the same optimal yields with NH_4 and with NO_3 but NH_4 was somewhat superior for p_H values from 6.0 to 9.0, while NO_3 was somewhat superior when the p_H value of the solution was below 6.0.

Summarizing, for wheat, NH_4 appears to have been about as suitable as NO_3 , or even superior to it under some conditions. It again appears that the H-ion concentration of the medium may directly or indirectly influence the relative effectiveness of these two sources of N.

Summary for Gramineae

It appears that all the Gramineae tested were capable of deriving at least a portion of their needed N from NH_4 as well as from NO_3 , but that the use of NH_4 as the only source of N has sometimes appar-

ently resulted in secondary conditions that were more or less injurious to the plants, notably high H-ion concentration of the medium. Different plant forms appear to differ in regard to their capacity to thrive with NH_4 as the only source of N and different varieties of the same species, as well as different developmental phases of the same form, have shown marked differences in this regard. The total concentration of the nutrient solution used and the partial concentrations of its component compounds (including the source or sources of N) appear to have exerted influences, either through resultant high H-ion concentration or otherwise, upon the apparent effectiveness of NH_4 and NO_3 as sources of N. Frequency of renewal of nutrient solutions has also been influential, as should be expected, since the composition of a solution in cultures without adequate renewal is subject to more or less rapid alteration through differential absorption by the plants.

Definite conclusions as to the relative capacities or nitrogen preferences of these different plant forms are not yet permissible, but it may be said that rice has greatly surpassed the other Gramineae tested, with respect to its tolerance of such injurious or retarding influences as may have resulted from the employment of NH_4 as sole nitrogen source. Under the various conditions of the experiments that have been carried out, rice has generally seemed to prefer ammoniacal N to nitrate N but it has grown better with NH_4NO_3 than with NH_4 alone as source of N. Maize and wheat appear to have grown about as well with NH_4 as with NO_3 , under suitable conditions, but different sets of experimental conditions seem to have swung the apparent nitrogen preference to one or the other of these two sources; sometimes one was somewhat superior and sometimes the other. Maize has

given better growth with NH_4NO_3 than with either NH_4 or NO_3 alone. Sorghum appears to have preferred NO_3 to NH_4 although the latter gave fair growth in some tests and good growth resulted from the use of NH_4NO_3 . Sugar cane seems to have preferred NO_3 to NH_4 in early phases of development, while NH_4 or NH_4 and NO_3 together (NH_4NO_3) were superior to NO_3 alone in more nearly mature phases. Barley, oats and rye have generally given poor growth when N was supplied only as NH_4 , while NO_3 generally gave very good growth. In no case did either of these three plant forms show superiority of NH_4 ; they seem to have been more sensitive to acidity of the medium than were any of the other Gramineae for which experiments have been reported. Barley has given good growth with NH_4NO_3 as double source of N. The use of this double source led, in some tests, to better growth than was given by either NH_4 or NO_3 alone, for rice, maize and the more advanced phases of sugar cane.

HYDROCHARITACEAE

Pirschle's (121) tests appear to indicate that NO_3 was more favorable than NH_4 for the submerged aquatic, *Elodea canadensis*, excepting when the medium had p_{H} value of 5.0, when NH_4 was superior to NO_3 .

LEGUMINOSAE

It is well known that legumes are able to obtain most, if not all, of their nitrogen requirements through symbiosis with nodule-forming bacteria when these are present, but it is also true that nitrogen compounds may be absorbed from the soil by these plants. The relations of leguminous plants to nitrogen compounds in the medium about the roots are especially difficult to study, since not only the nitro-

gen bacteria of the soil but also the symbionts need to be excluded from experimental cultures, or else taken quantitatively into account. For convenience, the notes of this section will be presented in a series of subsections representing the several plant forms considered.

Bean (Phaseolus vulgaris, P. multiflorus)

As early as 1842 de Saussure (137) reported that bean plants in sterilized sand were able to obtain their needed N from NH_4NO_3 . Rautenberg and Kühn (134) reached the same conclusion, finding that NH_4NO_3 , in solution cultures, gave better growth than was obtained when NO_3 was the only source of N. The use of NH_4 as the only source of N gave poor growth, but it led to a somewhat greater yield of seed than was obtained when NH_4NO_3 was used. Griffiths (44), growing young bean plants in sterilized solutions, found that they thrive with $(\text{NH}_4)_2\text{SO}_4$ as the only source of N. With cultures of bean in sterilized and in unsterilized soil, Pitsch (123) obtained generally better growth and earlier ripening of seed when N was supplied as NO_3 than when NH_4 was the only nitrogen source. Nodules were plentiful on the roots of the plants in unsterilized soil but were not present when the soil had been sterilized. Loo (87, 88) found, with solution cultures of this plant, that NaNO_3 was superior to NH_4NO_3 , NH_4Cl and $(\text{NH}_4)_2\text{SO}_4$; but NH_4HPO_4 led to as good growth as was obtained with NaNO_3 . In Pirschle's (119, 120, 121) solution cultures, both without renewal and with continuous flow, scarlet-runner bean (*Phaseolus multiflorus*) generally gave greater dry weights with NO_3 than with NH_4 , but in one series of tests with continuous flow these two sources of N were about equally effective. Pirschle's scarlet-runner bean plants did not appear to be very sensitive to differ-

ences in H-ion concentration, but continuous-flow cultures gave greatest dry weights with $(\text{NH}_4)_2\text{SO}_4$ when the p_{H} value of the solution was 6.0, the weights being smaller when the p_{H} value was lower or higher.

Pea (Pisum sativum)

Ehrenberg (31) cites Hosäus (60, 61, 62) as having shown that pea thrive as well when supplied with NH_4 as when furnished with NO_3 as its source of N. Mazé (94) found with sterilized-solution cultures that pea grew very well when supplied with N only in the ammoniacal form. In Kossowitsch's (74) sterilized-sand cultures this plant gave good growth with N supplied as either $\text{Ca}(\text{NO}_3)_2$ or $(\text{NH}_4)_2\text{SO}_4$. Prianischnikow (129) obtained good growth of pea in sand cultures with NH_4HCO_3 as nitrogen source, better than with NH_4Cl . Hutchinson and Miller (63, 64) studied the nitrogen nutrition of pea with special precautions to avoid nitrifying bacteria, reporting that NaNO_3 and $(\text{NH}_4)_2\text{SO}_4$ gave good and approximately equal dry weights; some amino compounds gave better yields than were obtained with $(\text{NH}_4)_2\text{SO}_4$. Zaleski and Tutorski (165) obtained better growth of pea seedlings with NO_3 than with an ammonium phosphate, but sodium aspartate led to as good development as was obtained with NO_3 . Schulow (142) obtained better growth of pea with $\text{Ca}(\text{NO}_3)_2$ than with NH_4NO_3 . As in the case of bean, Loo's (87, 88) experiments with pea showed NaNO_3 superior to $(\text{NH}_4)_2\text{SO}_4$, NH_4Cl or NH_4NO_3 , but NH_4HPO_4 was as good as NaNO_3 . In Pirschle's (119, 120, 121, 122) experiments, pea gave better growth with NO_3 than with NH_4 , whether the nutrient medium was continuously renewed or remained unchanged, and for a wide range of p_{H} values.

Vetch (Vicia)

In Mazé's (94) sterilized-solution cultures he found, for vetch as well as for pea, that NH_4 and NO_3 both led to good growth, being about alike. Prianschnikow (126) found, in sand-culture experiments, that vetch grew about equally well with either $\text{Ca}(\text{NO}_3)_2$, NaNO_3 or NH_4NO_3 , but failed when N was supplied as $(\text{NH}_4)_2\text{SO}_4$. As for bean and pea, so also for vetch, Loo's (87, 88) solution cultures gave better growth with NaNO_3 than with NH_4NO_3 , NH_4Cl or $(\text{NH}_4)_2\text{SO}_4$. Pirschle's (119, 121) results for vetch were also like those for bean and pea, NO_3 being superior to NH_4 for a wide range of p_H values. Windsor bean (*Vicia faba*), however, gave as good growth with NH_4 as with NO_3 , when the p_H value of the solution was 5.0 or 6.0.

Lupines (Lupinus luteus, L. angustifolius, L. albus)

Lehmann (82) reported experiments with yellow lupine grown in sterilized sand, in which NaNO_3 gave much better growth than was obtained with $(\text{NH}_4)_2\text{SO}_4$. The seed yield was greater, however, from the plants supplied with the ammonium salt, in which case symbiotic bacteria were probably present, supplying fixed nitrogen derived from the air. Prianschnikow's (129) results with lupine in sand cultures showed that $\text{Ca}(\text{NO}_3)_2$, NaNO_3 and NH_4NO_3 were highly and about equally effective but $(\text{NH}_4)_2\text{SO}_4$ failed to give even fair growth. Loo's (87, 88) solution cultures of lupine showed that NH_4NO_3 was effective as nitrogen source and about equal to NaNO_3 . In solution cultures, with continuous flow as well as without solution renewal, Pirschle (119, 121) obtained optimal yields of yellow lupine with NO_3 but NH_4 was also effective and it equalled NO_3 when the p_H value of the solution was 3.2, 4.5, 7.1 or 8.4.

In sand cultures of blue lupine, with frequent washing and renewal of the solutions, the same author found that NO_3 was superior to NH_4 , with a p_H value of 4.5 or 8.4, but NH_4 was about as effective as NO_3 when the p_H value of the solution used was 3.2, 5.8, or 7.1. The very best yields were obtained with NO_3 .

Clover (Trifolium)

Knop (71) reported that clover was able to thrive in pots of soil supplied with NH_4 , while hippuric acid and urea affected the plants injuriously.

Alfalfa (Medicago sativa)

Pirschle's tests (119, 120, 121) with alfalfa gave better growth with NO_3 than with NH_4 .

Soy-bean (Glycine hispida)

Shive (144) found that NH_4 salts were toxic to soy-bean in solution culture. Wolkoff (164) obtained better growth of soy-bean in solution cultures with $(\text{NH}_4)_2\text{SO}_4$ and $\text{Ca}(\text{NO}_3)_2$ applied together than when KNO_3 was applied with $\text{Ca}(\text{NO}_3)_2$. In Pirschle's (119, 121) sand-culture tests NO_3 gave better growth than was given by NH_4 , but other experiments indicated that this plant might do equally well with NH_4 as source of N if the effects of "physiological acidity" were avoided, as by means of solution cultures with continuous flow. When acidification was prevented in solution cultures NH_4 proved superior to NO_3 if the p_H value of the solution was 6.0 or 8.0. Tiedjens and Robbins (150) grew soy-bean plants in sand cultures with N supplied as $(\text{NH}_4)_2\text{SO}_4$ or as NH_4OH and with a p_H value of 7.0-8.8. Both of these sources of N gave very good growth, being equal or superior to $\text{Ca}(\text{NO}_3)_2$, but the sulphate was surpassed by the hydroxide.

Sensitive Plant (Mimosa pudica)

Bouchardat (16) placed cuttings of sensitive plant in solutions for rooting and observed that those in solutions containing NH_4 failed to develop.

Summary for Leguminosae

It appears that leguminous plants have been generally found to be capable of absorbing and assimilating NH_4 as well as NO_3 . Bean and lupine generally seem to have preferred NO_3 to NH_4 as source of N, when NH_4 was supplied as salts of strong acids. For pea, some experiments have shown NO_3 to be superior to NH_4 and other experiments indicated that these two ions were about equally effective. Soy-bean seems to have been more susceptible than bean, lupine or pea to the physiological acidity resulting from the presence of NH_4 salts of strong acids, but nevertheless this plant seems to have been better suited to NH_4 nutrition than either of the other forms just mentioned.

With the exception of soy-bean in some experiments, none of the legumes tested appears to have given as large yields with NH_4 (and any tested p_H values) as were obtained with NO_3 when the p_H value of the solution was optimal for growth with NO_3 . These plants seem to have been generally shown to be more or less unsuited to NH_4 and when both NH_4 and NO_3 were supplied together growth was not better than with NO_3 alone.

LILIACEAE

Aso and Behadur (6) obtained much better growth of onion (*Allium cepa*) when N was supplied as $(\text{NH}_4)_2\text{SO}_4$ than when it was supplied as NaNO_3 .

LINACEAE

In Pantanelli and Severini's (108) experiments flax (*Linum usitatissimum*) showed as good growth with NH_4Cl ,

$(\text{NH}_4)_2\text{SO}_4$ or NH_4NO_3 as was obtained when N was supplied as NaNO_3 . Ammonium tartrate gave optimal yields and NH_4HPO_4 was inferior to each of the first three salts mentioned. Pirschle (121) obtained equally good growth of flax with NH_4 and with NO_3 when his nutrient solutions were not renewed, but with continuously flowing solutions and a p_H value of 6.0, NH_4 gave better growth than was given by NO_3 . These two ions were equally good when the flowing solutions had a p_H value of 4.0, 8.0 or 9.0.

MALVACEAE

In experiments on cotton (*Gossypium*), Holley, Pickett and Dulin (57) found that KNO_3 gave larger dry-weight yields than were obtained when N was supplied only as $(\text{NH}_4)_2\text{SO}_4$. Tiedjens and Robbins (150), using sand cultures of cotton, compared $(\text{NH}_4)_2\text{SO}_4$ and NH_4OH with $\text{Ca}(\text{NO}_3)_2$, finding that NH_4 gave as good growth as was given by the nitrate. Ammonium hydroxide led to even more vigorous growth than was obtained with the sulphate and no ammonium toxicity was observed. Best growth occurred with NH_4 when the p_H value of the medium was about 7.5 or 8.0. The disagreement between these results and those reported by Holley, Pickett and Dulin may be due to differences in the H-ion concentration of the solutions used. Naftel (102) has recently stated that his solution cultures and sand cultures of cotton showed that NH_4 and NO_3 together gave better growth than was given by either NH_4 or NO_3 as sole source of N; fruiting was earlier and more fruits were borne when both NH_4 and NO_3 were supplied together. Friedmann (37) appears to have carried out culture experiments with cotton using continuously flowing solutions with various H-ion concentrations. He employed $(\text{NH}_4)_2\text{SO}_4$, NH_4OH and KNO_3 . Results

were to be reported in a later paper, which has not been seen by the writer.

MUSACEAE

Espino and Viado (34) found, with solution cultures of abaca (*Musa textilis*), that $(\text{NH}_4)_2\text{SO}_4$ was "a far better source of nitrogen" than NaNO_3 .

POLYGONACEAE

Buckwheat (*Fagopyrum esculentum*) was found by Lehmann (82) to prefer NO_3 to NH_4 , but Ville (158) obtained good growth of this plant when N was supplied only as NH_4Cl or as organic compounds. Pirschle (120, 121) found NO_3 superior to NH_4 for a broad range of p_{H} values of the medium.

ROSACEAE

Davis's (26) experiments with two-year old apple trees (*Malus malus*) in pots of sand showed no significant fertilizer effects of either $(\text{NH}_4)_2\text{SO}_4$ or $\text{Ca}(\text{CN})_2$, whether the solution used had been sterilized or not, but markedly improved growth followed the application of NaNO_3 . Tiedjens and Robbins (150) experimented with year-old apple trees grown in sand cultures in which they had been allowed to suffer from nitrogen deficiency, which gave yellow leaves. One group was treated with nutrient solution in which N was supplied as $\text{Ca}(\text{NO}_3)_2$ alone and another group received N only in the form of $(\text{NH}_4)_2\text{SO}_4$. Both solutions had a p_{H} value of 5.4. The foliage of the NH_4 plants remained yellow but that of the NO_3 plants became green. But complete recovery of the NH_4 plants occurred when the p_{H} value of the solution used was 8.0. In the same paper these authors state that the foliage of peach seedlings in sand culture was yellow when N was supplied

only as $(\text{NH}_4)_2\text{SO}_4$ with p_{H} value of 5.4, but the leaves became green subsequently, after the p_{H} value had been changed to 8.0.

SOLANACEAE

Potato (*Solanum tuberosum*) was the subject of early experiments by Bouchardat (17), who used boxes of soil. He failed to obtain increased yields with ammonium salts. Stohmann (148), who used solution cultures, reported better growth of potato when NH_4NO_3 and $\text{Ca}(\text{NO}_3)_2$ were applied together than when KNO_3 and $\text{Ca}(\text{NO}_3)_2$ were applied together. Krüger (79) concluded, from soil-sand cultures, that this plant preferred NH_4 to NO_3 , as source of N. His conclusion may refer to yield of tubers only, for his total-weight data show NH_4 superior in one test and NO_3 superior in another test and his results differ with respect to the concentrations employed. It apparently made no difference whether the soil-sand mixture had been sterilized or not.

Tobacco (*Nicotiana tabacum*), in Lehmann's tests (82), was greatly benefited by NaNO_3 but $(\text{NH}_4)_2\text{SO}_4$ led to yields twice as large as were obtained with NaNO_3 . On the other hand, Pirschle (119) found that NO_3 was superior to NH_4 for tobacco. Wagner (162) reported that the burning quality of tobacco leaves was improved by the use of $(\text{NH}_4)_2\text{SO}_4$ as fertilizer but de Vries (160) thought that the burning quality was not influenced by fertilizer treatment. Using sterilized-solution cultures of tobacco Beaumont and his co-workers (11) reached the conclusion that nitrates were more readily assimilated than any of the other nitrogen sources tested; urea gave less satisfactory results, and NH_4 gave still poorer growth. They thought the unsuitability of NH_4 for tobacco might be only partially due to physiological acidity, as considered by

Prianischnikow (130), or to H-ion concentration, as considered by Mevius (97).

Tomato (*Lycopersicon esculentum*) was included in the sand-culture experiments of Tiedjens and Robbins (150), who compared $(\text{NH}_4)_2\text{SO}_4$ and NH_4OH with $\text{Ca}(\text{NO}_3)_2$ and found that NH_4 gave as good growth as was given by NO_3 . Ammonium hydroxide with p_{H} value of 7, 8 or 9 was especially satisfactory and no injurious effects due to NH_4 were observed. (See the photographs shown in figure 4 of the paper just cited.)

UMBELLIFERAE

According to Pfeiffer, Hepner and Frank (117), NaNO_3 was superior to NH_4NO_3 and the latter was superior to $(\text{NH}_4)_2\text{SO}_4$, for growth of carrot (*Daucus carota*).

IV. CONCLUSION

Although the review presented in this paper is not to be considered as complete, it is probably fairly representative of the technique and trend of investigation in this field. Many different forms of higher green plants have been studied by numerous experimenters. Experimental technique has been continually improved. Nevertheless, it is apparent that the results reported do not yet lead to satisfactory general conclusions. It appears that the NO_3 ion is a suitable source of nitrogen for higher green plants in general but many forms have been found to thrive with the NH_4 ion as sole nitrogen source. In some cases these two ions, when supplied separately, showed about the same degree of effectiveness; in some other cases NO_3 was superior to NH_4 , although the latter was nutritionally effective to a considerable extent; in a few cases NH_4 was found to be definitely superior to NO_3 ; and a good many tests indicated that NH_4NO_3 (which supplies both NH_4 and NO_3) was equal or superior to either one of these two ions

supplied separately. Not only have different kinds of plants been found to show marked differences in their capacity to thrive with NH_4 as the only source of nitrogen, but different experimenters have in many instances obtained very different results with the same kind of plant, and separate but similar tests of the same plant by the same investigator have led to discordant results in some instances. It seems clear that such disagreement must be related to experimental influences or conditions that have not as yet been adequately reckoned with. A number of conditions that may possibly be involved will readily suggest themselves.

Differences among different plant forms, with regard to their NH_4 and NO_3 relations, are very striking and disconcerting when one tries to summarize these relations for higher green plants in general. There seems to be no reason for doubting that species and varieties probably do differ greatly in this as well as in many other respects, but the plants studied cannot yet be classified according to their preferences in respect to nitrogen supply. The apparent differences indicated by the literature and reflected in this review are not to be taken as really very well established, however, since the many experiments dealt with are generally not truly comparable in any satisfactory sense. Relatively slight differences in experimental technique may possibly account for great differences in results, without the supposition that the various plant forms are really as different as they appear to be. It is of course essential that the plants used in any series of comparable tests should be as nearly alike as possible at the beginning for all tests and varieties and genetic strains, as well as species, need consideration if definite results are to be expected from comparative experiments. Furthermore, the preliminary treatment of

the plants used (as in seed germination, for example) needs to be standardized, lest different lots of plants of the same form may differ in physiological vigor. The developmental phase of the plants used appears to be of great importance; nutritional requirements for different developmental phases and different degrees of vigor may be very different for the same variety of plant. Germinating seeds, sprouting eyes (as of sugar cane or potato), young plants, older plants, mature plants, all of the same species and strain, may be expected to perform more or less differently when exposed to the same environmental complex. Since the plants of an experiment change as they become older the time factor is naturally a crucial variable; results obtained with a longer experiment period may be quite unlike those obtained with a shorter period, even if all experimental features excepting duration are closely similar in the two cases.

In many instances it is difficult or impossible to institute useful comparisons among the results obtained in several different experiments because of the employment of different criteria in judging growth and development. A great variety of plant criteria have been used by experimenters on plant nutrition and different criteria may indicate markedly different relations to nutritional conditions. Green weight, dry weight, height, transpiration, leaf area, color, branching, flowering, fruit production, tuber production, are examples. Grain production and straw production are often compared, as in agronomic studies on cereals. Quality of the product is sometimes considered as well as quantity, and this consideration introduces many special kinds of criteria. Earliness or promptness of flowering, fruiting, and other events in the life cycle are sometimes important considerations in nutrition experiments; thus, if two differ-

ent nutrient solutions are compared, with all other environmental influences alike, both may give sensibly the same result at the end of a sufficiently long experiment period, but flowering or fruiting may occur much earlier with one solution than with the other. Comparisons of growth vigor in different regions of the plant body may bring out important nutritional relations; for example, NH_4 has been found, in some of the writer's experiments, to give less root growth of sugar cane than was shown when nitrogen was supplied only as NO_3 , while NH_4 appeared to be superior for top growth. The ratio of tops to roots may be a useful criterion for comparing cultures with respect to growth in general; in some tests ammoniacal nitrogen led to much more vigorous tillering in sugar cane than was obtained with NO_3 .

Various special plant criteria refer to diseased conditions of the plants; for example, Tottingham's (153) magnesium injury to wheat foliage, which has recently been studied by Trelease and Trelease (157), and Espino's (33) ammonium injury to rice leaves. When diseased conditions occur they should naturally be taken into account, along with weight values or whatever general criteria are employed.

However species and varieties and different developmental stages of the same form may differ, there is certainly no doubt that the kind and degree of the nutritional response shown by any given plant species or variety toward any specified substance or ion is influenced not only by the nature and concentration of the substance or ion specially considered but also by concentrations and relative proportions of many other molecules and ions that are concomitantly present and effective in the nutrient medium. Hydrogen-ion concentration has recently been studied a great deal in connection with nitrogen nutrition and

other non-nitrogenous ions have received attention from some experimenters.

We may consider H-ion concentration for a useful illustration of the complications that became obvious as soon as non-nitrogen conditions are taken into account. Suppose that two fairly comparable series of satisfactory solution cultures have been simultaneously carried out with suitable plants, the sole nitrogen source being NO_3 for one series and NH_4 for the other. Also suppose that each series has included a number of different but maintained p_{H} values of the solution, ranging from 4.0 to 9.0. The results might show that the p_{H} value of the optimal solution of the NO_3 series is 6.0, with a growth index of 1.10, while the p_{H} value of the optimal solution of the NH_4 series might be 8.0, with a growth index of 1.00. This might lead to the conclusion that the plants used, under the general conditions of this hypothetical series of experiments, had apparently preferred NO_3 to NH_4 as source of nitrogen, for the greatest growth index is shown for NO_3 ; but it would be noted that the best solution with NH_4 led to almost as good growth as was given by the best solution with NO_3 . Such a conclusion would be based on the more general optima, without reference to p_{H} value, but a quite different conclusion might be reached if comparisons were instituted in the other direction, each two solutions with the same H-ion concentration being compared. For example, with p_{H} value of 6.0 the hypothetical growth indices for NO_3 and NH_4 might be respectively 1.10 and 0.80; and with p_{H} value of 8.0 the corresponding indices might be 0.80 and 1.00 respectively. From the first comparison (with p_{H} value of 6.0) NO_3 would appear to have been preferred to NH_4 , but the second comparison (with p_{H} value of 8.0) would lead to the opposite conclusion. A study of the complete double series might lead to the gen-

eralization that NO_3 appeared to have been superior to NH_4 with suitably acid solutions but that NH_4 appeared to have been superior to NO_3 with suitably alkaline solutions.

Different plant forms have been found to differ in their preferences for p_{H} value of the medium as well as for nitrogen source. The complex problem of optimal H-ion concentration for the health of higher plants is discussed by Mevius (98), Arrhenius (5) and others. Whether NO_3 or NH_4 may be superior or inferior seems to depend largely on suitable adjustment of the environmental conditions other than nitrogen supply, notably H-ion concentration. The employment of NH_4 salts of strong acids as source of nitrogen is apt to result in H-ion concentration too high for healthy development in many instances. The eventual nutritional effectiveness of NH_4 for any plant seems therefore to be related, in many instances, to the degree of tolerance exhibited by the plant toward such resultant "physiological acidity." Rice appears to have shown generally a high degree of acidity tolerance.

The hypothetical example discussed above may illustrate, as a general and fundamental principle, how important it is to include a representative range of p_{H} values in experimentation on nitrogen sources, and the same general principle requires attention with regard to other influential conditions, not only the concentrations of the other effective non-nitrogenous ions (as Ca^{++} , HPO_4^- , etc.) but the total osmotic value of the medium, temperature and temperature fluctuation, light intensity, quality of light and light fluctuation, and so on. Even for an adequately specified kind of plant, in an adequately specified developmental phase, it would be impossible to state definitely that either the NO_3 ion or the NH_4 ion is

always preferable to the other ion, for apparent preference in such a case is clearly conditioned by non-nitrogen features of experimental environment. When field culture is considered the theoretical problem of nitrogen sources becomes vastly more complicated, because of the practical impossibility of even attempting to take all influential environmental features into account. It is consequently not surprising that the very extensive literature of field tests with various nitrogen fertilizers is characterized by even greater discrepancy (at least as far as theory is concerned) than is shown by the literature of physiological cultures with which this paper deals.

As to the other non-nitrogenous ions commonly present in experimental media, the partial concentrations of PO_4 , Ca, Mg, etc., may be expected to influence not only H-ion concentration but also a plant's response to a given concentration of NH_4 or NO_3 when applied along with a specified H-ion concentration. Many different experimental solutions might be made up so as to have the same p_{H} value and the same partial concentration of NH_4 , but they would hardly be expected to be alike in nutrient effectiveness unless their other components had been suitably adjusted. Since the solutions used in different experiments on nitrogen nutrition have been very various with respect to their non-nitrogen constituents (even when their H-ion concentrations have been taken adequately into account) it is easy to suggest possible explanations for apparently discrepant results on this ground alone.

It has been noted that for physiological experimentation (as different from agronomic or other technological studies) soil cultures are unsuitable because of the innumerable unknown variables involved, but sand cultures have been used with relatively satisfactory results by many

students of the problem of nitrogen nutrition, since such cultures bring into account some of the simpler soil features without necessarily complicating the experimentation to a hopeless degree. However, solution cultures naturally furnish the least troublesome procedure for experimentation and for the logical analysis of experimental results. Data derived from sand cultures may be very difficult to compare with corresponding data derived from solution-culture experiments, as is to be seen at various places in the present review. Such comparisons have been made by Shive and W. H. Martin (145), Hoagland and J. C. Martin (56) and Bakke and Erdman (8).

Another important possible source of discrepancy in experimentation on nitrogen sources, as well as on other phases of the problem of salt nutrition, refers to alterations that may occur in nutrient solutions after the plants have been introduced. This suggests not only the comprehensive question of differential absorption and possible excretion by plant roots but also the question of the presence or absence of micro-organisms in the experimental cultures, especially nitrifying and denitrifying bacteria. Trelease and Livingston (155), Allison (3), Allison and Shive (4), Shive and Stahl (146), Pirschle (119, 120, 121, 122) and others have indicated that continuously flowing solutions may be employed to avoid a number of fluctuating variables that are commonly encountered in culture experiments in which solutions are renewed at intervals. Flowing solutions have been employed by several experimenters in the study of nitrogen relations. It does not appear, however, that really satisfactory experimental procedure has thus far been at all widely applied for the prevention or quantitative experimental control of the effects of micro-organisms in culture solutions.

While arrangements are readily feasible by which a solution flowing into a culture jar is surely quite free from micro-organisms, yet it is not so easy to guard against the presence of micro-organisms on the roots of the plants when an experiment is started. Before really satisfactory experimental data on this question of the relative effectiveness of NH_4 and NO_3 can be made available the possibility of both nitrification and denitrification, as well as other changes apt to occur in the medium during a culture period, will need to be guarded against.

When continuous renewal of solutions is not resorted to, the relations between volume of culture jar, size of plants, number of plants per jar, concentrations and salt proportions of solutions, frequency of renewal of solutions and other related features, all surely require to be taken into account quantitatively. Perhaps many of the disagreements and apparent discrepancies of the literature reviewed in this paper may be related to some of these imperfectly understood variables.

Aeration of culture media is another feature of salt-nutrition experimentation that deserves serious attention, not only with reference to oxygen supply but also with reference to CO_2 concentrations and perhaps to concentrations of other volatile substances that may emanate from the roots or arise in the solutions. This feature may be standardized through the use of suitable arrangements for continuous renewal of solutions (3, 4).

Turning to the physical environment of experimental cultures, temperature, light quality, light intensity and fluctuations of light and temperature, are among the unknown or inadequately specified influences to which may be related some of the present confusion concerning nitrogen sources for green plants. Diurnal periodicity of temperature or of light, or both, may well

be of paramount importance. The season of the year at which an experiment is performed may perhaps be indirectly influential in determining what sort of results may be obtained when two different solutions are compared (40).

LIST OF LITERATURE

1. ADDOMS, RUTH M., and F. C. MOUNCE. Notes on the nutrient requirements and the histology of the cranberry (*Vaccinium Macrocarpon* Ait.) with special reference to mycorrhiza. *Plant Physiol.*, 6: 653-668. 1931.
2. ALLISON, F. E. Forms of nitrogen assimilated by plants. *QUART. REV. BIOL.*, 6: 313-321. 1931.
3. ALLISON, R. V. Effect of aeration and continuous renewal of nutrient solutions upon the growth of barley and buckwheat in artificial culture. *N. J. Agric. Exp. Sta. Repts.*, 1922: 402. 1923.
4. ——— and J. W. SHIVE. Studies on the relation of aeration and continuous renewal of nutrient solution to the growth of soybean in artificial culture. *Amer. Jour. Bot.*, 10: 554-566. 1923.
5. ARRHENIUS, O. Kalkfrage, Bodenreaktion und Pflanzenwachstum. *Leipzig*, 1926.
6. ABO, K., and RANA BHADUR. On the influence of the reaction of the manure upon the yield. *Bull. Coll. Agric. Tokyo*, 7: 39-46. 1906.
7. ATKINS, W. R. G. Some Recent Researches in Plant Physiology. *London*, 1916.
8. BAKKE, A. L., and L. W. ERDMAN. A comparative study of sand and solution cultures for Marquis wheat. *Amer. Jour. Bot.*, 10: 18-31. 1923.
9. BARTHOLOMEW, R. P. The availability of nitrogenous fertilizers to rice. *Soil Sci.*, 28: 85-100. 1930.
10. BARTON-WRIGHT, E. C. Recent Advances in Plant Physiology. *Philadelphia*, 1930.
11. BRAUMONT, A. B., G. J. LARRINOS, P. PIERENBROCK, and P. R. NELSON. The assimilation of nitrogen by tobacco. *Jour. Agric. Res.*, 43: 559-567. 1931.
12. BENECKE, W., and L. JOST. Pflanzenphysiologie. 2 vols. (viii + 441 p., viii + 477 p.), 4th ed. *Jena*, 1924.
13. BENNER, A. Einige Beobachtungen bei den dreijährigen Vegetationsversuchen in wässrigen Lösungen. *Landw. Versuchsst.*, 9: 480-482. 1867.
14. ———. Bericht über die Sommer 1867 an der Versuchstation Regenwalde ausgeführten

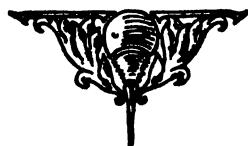
- Wasserculturversuche. *Landw. Versuchsst.*, 11: 262-287. 1869.
15. BIRNER, H., and B. LUCANUS. Wasserculturversuche mit Hafer. *Landw. Versuchsst.*, 8: 128-177. 1866.
 16. BOUCHARDAT, A. Influence des composés ammoniacaux sur la végétation. *Compt. Rend. Acad. Sci. (Paris)*, 16: 322-324. 1843.
 17. ——— Expérience concernant l'action des sels ammoniacaux sur la récolte de la pomme de terre, et observations concernant l'influence de la température sur le développement des tubercules. *Compt. Rend. Acad. Sci. (Paris)*, 21: 636-637. 1845.
 18. BOUMINGAULT, JEAN B. J. D. De l'action du salpêtre sur la végétation. *Ann. Sci. Nat. Bot.*, IV, 4: 32-46. 1855.
 19. BRIGHAM, R. O. Assimilation of organic nitrogen by *Zea Mays* and the influence of *Bacillus subtilis* on such assimilation. *Soil Sci.*, 3: 155-195. 1917.
 20. CLAUSEN, P. Zur Frage: Ammoniak oder Salpeter? *Landw. Zeitg.*, 84: 892. 1903. Also *Biedermanns Centrbl. Agrik. Chem.*, 33: 434-437. 1904.
 21. CLEMENTS, F. C. Plant Physiology and Ecology. iv + 315 p. New York, 1907.
 22. COULTER, J. M., C. R. BARNES and H. C. COWLES. A Textbook of Botany. Vol. II, Physiology, rev. and enl. by C. A. Shull. New York, 1930.
 23. CZAPK, FRIEDRICH. Biochemie der Pflanzen. Bd. 2. Jena, 1925.
 24. DAIKUKARA, G., and T. IMASEKI. On the behavior of nitrate in paddy soils. *Bull. Imp. Centr. Agr. Exp. Sta. Japan*, 1: 7-36. 1907.
 25. DARWIN, F., and E. H. ACTON. Practical Physiology of Plants. xix + 340 p. Cambridge (England), 1909.
 26. DAVIS, M. B. The influence of ammonium sulphate as a direct source of nitrogen for apple trees. *Sci. Agric. (Canada)*, 8: 41-55. 1927. (From *Exp. Sta. Rec.*, 58: 38. 1928.)
 27. DETMER, W. Practical Plant Physiology. (Trans. by S. A. Moor.) xix + 555 p. London, 1909.
 28. DIKUMAR, I. G. Relative Wirkung von Nitraten und Ammoniumsätzen auf das Pflanzenwachstum und die Abhängigkeit dieser Wirkung von der Wasserstoff- und Calcium-ionkonzentration der Nährlösung. *Jour. f. Landw. Wiss. (Moskau)*, 6: 74-83. 1929.
 29. DUMAS, J. Essai de statique chimique des êtres organisés. *Ann. Chim. et Phys.*, 4: 115-126. 1842.
 30. DUGGAR, B. M. Plant Physiology. xv + 516 p. New York, 1911.
 31. EHRENBURG, PAUL. Die Bewegung des Ammoniakstickstoffs in der Natur. *Mitt. Landw. Inst. K. Univ. Breslau*, 4: 47-300. 1907-09.
 32. ——— Beiträge zur Ammoniakfrage, I. *Landw. Versuchsst.*, 69: 259-294. 1908.
 33. ESPINO, R. B. Some aspects of the salt requirements of young rice plants. *Philippine Jour. Sci.*, 16: 455-525. 1920.
 34. ——— and O. VIADO. A preliminary study of the salt and fertilizer needs of the young abaca plant. *Philippine Agric.*, 12: 127-133. 1923.
 35. ——— and R. P. ESTIOKO. A critical study of the nutritive value of nitrate nitrogen for young rice plants. *Philippine Agric.*, 20: 27-42. 1931.
 36. EULER, H. Grundlagen und Ergebnisse der Pflanzenchemie. 2 vols. (ix + 238 p., viii + 297 p.) Braunschweig, 1909.
 37. FRIEDMAN, W. G. A method for comparing the value of ammonia and nitrate nitrogen. *Sci.*, 70: 43. 1929.
 38. FAKAKI, S. Über den Nährwert des Calciumnitrats und des Ammonium Sulfate als Stickstoffquelle zur Wasserkultur des Reispflanzen. *Bull. Sci. Fak. Terkult. Kjusu Imp. Univ. Fukuoka*, 3: 244-262. 1929. (From *Biol. Absts.*, 6: abst. 6548. 1932.)
 39. GANONG, W. F. A Laboratory Course in Plant Physiology. vi + 265 p. 2nd ed. New York, 1908.
 40. GERICKER, W. F. Influence of temperature on the relation between nutrient salt proportions and the early growth of wheat. *Amer. Jour. Bot.*, 8: 59-62. 1921.
 41. GERLACH and VOGEL. Ammoniakstickstoff als Pflanzennährstoff. *Centrbl. Bakt.*, III, 14: 124-128. 1905.
 42. GRAFTIAU, J. (Ammonia nitrogen in vegetable nutrition.) *Ann. Gembloux*, 32 (8): 169-178. 1926. (From *Biol. Absts.*, 2: abst. 561. 1928.)
 43. GREEN, J. REYNOLDS. An Introduction to Vegetable Physiology. 3d ed. ix + xxii + 469 p. Philadelphia, 1911.
 44. GRIFFITHS, A. B. On the direct absorption of ammoniacal salts by certain plants. *Chem. News*, 64: 147. 1891. Also see *Chem. Centrbl.*, 2: 820. 1891.
 45. HAAS, P., and T. G. HILL. An Introduction to the Chemistry of Plant Products. 2nd ed. xii + 411 p. London, 1917.
 46. HALL, SIR A. D. Fertilizers and Manures. x + 384 p. London, 1920.

47. HALL, SIR A. D. *The Soil*. 3d ed. xiii + 352 p. *London*, 1920.
48. HAMPE, W. Die Harnstoff als stickstoffhaltiges Pflanzennahrungsmittel. *Landw. Versuchsst.*, 7: 308-310. 1865.
49. ——— Ueber Harnstoff und Harnsäure als stickstoffhaltige Pflanzennahrungsmittel. *Landw. Versuchsst.*, 8: 225-235. 1866.
50. ——— Ueber die Assimilation von Harnstoff und Ammoniak durch die Pflanzen. *Landw. Versuchsst.*, 9: 49-70, 157-167. 1867.
51. ——— Vegetations-versuche mit Ammoniak-salzen, Harnsäure, Hippursäure, und Glyco-coll als stickstoffhaltigen Nahrungsmitteln der Pflanzen. *Landw. Versuchsst.*, 10: 175-187. 1868.
52. HARRISON, J. B., and R. WARD. Experiments with varieties of rice at the botanic gardens, 1913. *Jour. Board Agric. Brit. Guiana*, 7: 85-86. 1913.
53. HARRISON, W. H. The principles of paddy manuring. *Jour. Board Agric. Brit. Guiana*, 6: 37-40, 71-77. 1913.
54. HARVEY, R. B. *Plant Physiological Chemistry*. xix + 413 p. *New York*, 1930.
55. HOAGLAND, D. R. Mineral nutrition of plants. *Ann. Rev. Biochem.*, 1: 618-636. 1932.
56. ——— and J. C. MARTIN. A comparison of sand and solution cultures with soils as media for plant growth. *Soil Sci.*, 16: 367-387. 1923.
57. HOLLEY, K. T., T. A. PICKETT AND T. G. DULIN. A study of ammonia and nitrate nitrogen for cotton. I. Influence on absorption of other elements. *Georgia Exp. Sta. Bull.* 169. 1931.
58. HONCAMP, F. Handbuch der Pflanzenernährung und Düngerlehre. (2 vol. xv + 945, xii + 919 p.) *Berlin*, 1931.
59. HONERT, T. VAN DEN. (Physiological studies on sugar cane.) *Verslag Vereniging Proefsta. Java Suikerind.*, 1929, pp. 104-105.
60. HOSIUS, A. Ueber das Vorkommen und die Bestimmung des Ammoniaks und der Salpetersäure in den Pflanzen. *Zeitschr. deutsch. Landw.*, 15: 337-347. 1864.
61. ——— Ueber den Gehalt der Pflanzen an Ammoniak und Salpetersäure während der Vegetationsperiode. *Zeitschr. deutsch. Landw.*, 16: 97-108. 1865.
62. ——— Ueber den Einfluss verschiedener Nahrungsmittel auf den Ammoniak- und Salpetersäuregehalt der Pflanzen. *Zeitschr. deutsch. Landw.*, 17: 5-13. 1866.
63. HUTCHINSON, H. B., and N. H. J. MILLER. The direct assimilation of ammonium salts by plants. *Jour. Agric. Sci.*, 3: 179-194. 1909.
64. HUTCHINSON, H. B., and N. H. J. MILLER. The direct assimilation of inorganic and organic forms of nitrogen by higher plants. *Jour. Agric. Sci.*, 4: 282-302. 1912.
65. JAMES, W. O. An Introduction to Plant Physiology. viii + 259 p. *Oxford*, 1931.
66. JOSE, L. Lectures on Plant Physiology. (Transl. by R. J. H. Gibson.) xiv + 564 p. *Oxford*, 1907.
67. KALINIKIN, S. I. (The utilization of ammoniacal nitrogen by corn plantlets.) *Izv. Moskov. Sel'sk. Khoz. Inst.*, 18: 180-192. 1912. (From *Exp. Sta. Rep.*, 27: 634. 1912.)
68. KELLEY, W. P. The assimilation of nitrogen by rice. *Hawaii Agric. Exp. Sta. Bull.* 24. 1911.
69. ——— Rice soils of Hawaii. *Hawaii Agric. Exp. Sta. Bull.* 31. 1914.
70. KELLNER, O. I. Culturversuche mit Sumpfreis in wässrigen Lösungen. *Landw. Versuchsst.*, 30: 18-32. 1884. See also *Bot. Centrbl.*, 29: 223. 1887.
71. KNOP, W. Beitrag zur Beantwortung der Frage: Athmet eine gesunde Pflanze Ammoniak aus? *Landw. Versuchsst.*, 1: 162-164. 1859.
72. KONDO, MANTARO, and S. ISHIKI. Literaturverzeichnis über Reis und Reiskultur. *Ber. Obata Inst. Landw. Forsch. (Kuraschiki)*, 5: 325-346. 1932.
73. KOLKOWITZ, R. Pflanzenphysiologie. 258 p. *Jena*, 1914.
74. KOSOWITZCH, P. Ammoniaksalze als unmittelbare Stickstoffquelle für Pflanzen. *Jour. Exp. Landw. (Russia)*, 2: 637-638. 1901.
75. ——— Ueber die gegenseitige Einwirkung (Wechselwirkung) der Nährsalze bei der Aufnahme mineralischer Nahrung durch die Pflanzen. *Jour. Exp. Landw. (Russia)*, 5: 581-612. 1904.
76. KOSTYCHEV, S. Kostychev's Chemical Plant Physiology. (Transl. and ed. by C. J. Lyon.) xv + 407 p. *Philadelphia*, 1931.
77. KRAUM, F. G. Rice investigations—report of first year's experiments. *Hawaii Agric. Exp. Sta. Repts.*, 1907: 67-90. 1908.
78. ——— Field crop experiments. *Hawaii Agric. Exp. Sta. Repts.*, 1908: 65-84. 1909.
79. KRÜGER, W. Ueber die Bedeutung der Nitrifikation für die Kulturpflanzen. *Landw. Jahrb.*, 34: 761-782. 1903.
80. KÜHN, G. Notiz über das Ammonia, als pflanzlichen Nährstoff. *Landw. Versuchsst.*, 9: 167-168. 1867.
81. LATEROFF, ELBERT C. The organic nitrogen compounds of soils and fertilizers. *Jour.*

- Franklin Inst.*, 183: 169-206, 303-321, 465-498. 1917.
82. LEHMANN, J. Ueber die zur Ernährung der Pflanzen geeignetste Form des Stickstoffes. *Biedermanns Centrbl. Agric. Chem.*, 7: 403-409. 1875.
 83. LEFEBCHKIN, W. Pflanzenphysiologie. vi + 297 p. *Berlin*, 1925.
 84. LIBBIG, J. Die Chemie in ihrer Anwendung auf Agrikultur und Physiologie. 1840. Also: Chemistry in its Application to Agriculture and Physiology. 3rd ed. *Philadelphia*, 1843.
 85. LIPMAN, C. B., and J. K. TAYLOR. Do green plants have the power of fixing elementary nitrogen from the atmosphere? *Jour. Franklin Inst.*, 198: 475-506. 1924.
 86. LINSBAUER, L., and K. LINSBAUER. Vorschule der Pflanzenphysiologie. 2nd ed. xv + 255 p. *Wien*, 1911.
 87. LOO, T. L. The influence of hydrogen-ion concentration on the growth of the seedlings of some cultivated plants. *Bot. Mag. Tokyo*, 41: 33-41. 1927.
 88. ——— On the mutual effects between the plant growth and the change of reaction of the nutrient solution with ammonium salts as the source of nitrogen. *Jap. Jour. Bot.*, 3: 163-203. 1927.
 89. LYON, T. L., E. O. FIPPIN and H. O. BUCKMAN. Soils, Their Properties and Management. xxi + 763 p. *New York*, 1916.
 90. MACDOUGAL, D. T. Practical Textbook of Plant Physiology. xiv + 352 p. *New York*, 1908.
 91. MAXIMOV, N. A. A Textbook of Plant Physiology. (Transl. and ed. by A. E. Murneck and R. B. Harvey.) xvi + 381 p. *New York*, 1930.
 92. MAYER, ADOLF. Ueber die Aufnahme von Ammoniak durch oberirdische Pflanzentheile. *Landw. Versuchsst.*, 17: 329-397. 1874.
 93. ——— Die Düngung mit Kalisalzen. *Landw. Versuchsst.*, 26: 77-134. 1881.
 94. MAZÉ, P. L'assimilation de l'azote nitrique et de l'azote ammoniacal par les végétaux supérieurs. *Compt. Rend. Acad. Sci. (Paris)*, 127: 1031-1033. 1898.
 95. ——— Recherches sur l'influence de l'azote nitrique et de l'azote ammoniacal sur le développement du maïs. *Ann. Inst. Pasteur*, 14: 26-48. 1900.
 96. MCGORON, W. T. The assimilation of nitrogen by sugar cane. *Hawaii Planters Rec.*, 27. 1923.
 97. MEYER, W. Die Wirkung der Ammoniumsalze in ihrer Abhängigkeit von der Wasserstoffionkonzentration. I. *Planta*, 6: 379-455. *Idem*, and H. Engel. Same title. II. *Ibid.*, 9: 1-83. 1929.
 98. MEYER, W. Reaktion des Bodens und Pflanzenwachstum. *Freising-München*, 1927.
 99. ——— and I. DIKUMAR. Nitrite als Stickstoffquellen für höhere Pflanzen. *Jahrb. wiss. Bot.*, 73: 633-704. 1930.
 100. MILLER, E. C. Plant Physiology. xxiv + 900 p. *New York*, 1931.
 101. MÜNTZ, A. Sur le rôle de l'ammoniaque dans la nutrition des végétaux supérieurs. *Compt. Rend. Acad. Sci. (Paris)*, 109: 646-648. 1889.
 - ✓ 102. NAFFEL, JAMES A. The absorption of ammonium and nitrate nitrogen by various plants at different stages of growth. *Jour. Amer. Soc. Agron.*, 23: 142-158. 1931.
 103. NAGAOKA, M. On the behavior of the rice plant to nitrates and ammonium salts. *Bull. Coll. Agric. Tokyo*, 6: 285-334. 1904-05.
 104. NATHANSOHN, A. Der Stoffwechsel der Pflanzen. viii + 472 p. *Leipzig*, 1910.
 105. NEHRING, K. Die Ausnutzung der verschiedenen Stickstoffformen bei verschiedener Bodenreaktion. *Zeitschr. Pflanzenernähr. u. Düng.*, 7B: 180-183. 1928.
 106. PALISOC, E. Comparative nutritive values of different salts of ammonium. *Philippine Agric.*, 17: 37-43. 1928.
 107. PALLADIN, V. I. Plant Physiology. 3rd Amer. ed., ed. by B. E. Livingston. xxv + 360 p. *Philadelphia*, 1926.
 108. PANTANELLI, E., and G. SEVERINI. Alcune esperienze sulla nutrizione azotata delle piante verdi, con diversi sali d'ammonio. *Staz. Sper. Agr. Ital.*, 43: 449-544. 1910.
 109. ———, ———. Ulteriori esperienze sulla nutrizione ammoniacale delle piante verdi. *Staz. Sper. Agr. Ital.*, 44: 873-908. 1911.
 - ✓ 110. PARDO, J. H. Utilization of certain nitrogen compounds by the sugar cane. *Internat. Sugar Jour.*, 32: 11-19. 1930.
 - ✓ 111. ——— Ammonium versus nitrate as nitrogen source for the sugar cane. *Proc. Internat. Congr. Sugar cane Technologists Bull.* 13. 1932.
 112. PERICH, C. J. The Physiology of Plants. x + 363 p. *New York*, 1926.
 113. ——— Experimental Plant Physiology. vii + 166 p. *New York*, 1931.
 114. PEROTTI, RENATO. Su la nutrizione azotata della pianta. *Staz. Sper. Agr. Ital.*, 41: 593-608. 1908.
 115. PERCIABOSCO, F., and V. ROSSO. L'assorbimento diretto dei nitriti nelle piante. *Staz. Sper. Agr. Ital.*, 42: 5-36. 1909.
 116. PFEFFER, W. The Physiology of Plants. 2nd

- ed. (Transl. and ed. by A. J. Ewart) 3 vols : xii + 632 p., viii + 296 p., vii + 451 p. *Oxford*, 1906.
117. PFIFFER, TH., A. HEPNER and L. FRANK. Die Ausnutzung des Stickstoffs in Form von Salpetersäurem Ammoniak. *Miss. Landw. Inst. K. Univ. Breslau*, 4: 341-349. 1907-09.
118. PIERRE, W. H. Nitrogenous fertilizers and soil acidity. I. Effect of various nitrogenous fertilizers on soil reaction. *Jour. Amer. Soc. Agron.*, 20: 254-269. 1928.
119. PIRCHLE, K. Nitrate und Ammonsalze als Stickstoffquellen für höhere Pflanzen bei konstanter Wasserstoffionenkonzentration. *Planta*, 9: 84-104. 1929.
120. ——— Same title, II. *Ber. deutsch. bot. Ges.*, 47: (86)-(92). 1929.
121. ——— Same title, III. *Planta*, 14: 583-676. 1931.
122. ——— Same title, IV. *Zeitschr. Pflanzenernähr.*, A, 22: 51-86. 1931.
123. PITICH, O. Versuche zur Entscheidung der Frage, ob Salpetersäure Salze für die Entwicklung unserer landwirtschaftlichen Kulturgewächse unentbehrlich sind oder nicht. *Landw. Versuchsst.*, 34: 217-258. 1887.—*Ibid.*, 42: 1-95. 1893.—*Ibid.*, 46: 357-370. 1896.
124. PRIANISCHNIKOW, D. Ueber die Ausnutzung der Phosphorsäure der schwerlöslichen Phosphate durch höhere Pflanzen. *Ber. deutsch. bot. Ges.*, 18: 411-416. 1900.
125. ——— Zur Frage ueber den relativen Wert von verschiedenen Phosphaten. *Landw. Versuchsst.*, 56: 107-140. 1901.
126. ——— Ueber den Einfluss von Ammoniumsalzen auf die Aufnahme von Phosphorsäure bei höheren Pflanzen. *Ber. deutsch. bot. Ges.*, 23: 8-17. 1905.
127. ——— Zur physiologischen Charakteristik der Ammoniumsalze. *Ber. deutsch. bot. Ges.*, 26: 716-724. 1908.
128. ——— Sur l'assimilation de l'ammoniaque par les plantes supérieures. *Compt. Rend. Acad. Sci. (Paris)*, 177: 603-606. 1923.
129. ——— Ueber die Verhalten gegen Kohlensäuren Ammoniak der Pflanzen. *Jour. Landw. Wiss. (Russia)*, 1: 179-190. 1924.
130. ——— Ammoniak, Nitrate und Nitrite als Stickstoffquellen für höhere Pflanzen. *Ergeb. Biol.*, 1: 407-446. 1926.
131. ——— Zur Frage nach der Ammoniakernährung von höheren Pflanzen. *Biochem. Zeitschr.*, 207: 341-349. 1929.
132. ——— and M. K. DOMONTOVITCH. The problem of a proper nutrient medium. *Soil Sci.*, 21: 327-348. 1926.
133. RAMER, O. L. Principles of Plant Physiology. xii + 377 p. *New York*, 1928.
134. RAUTENBERG, F., and G. KÜHN. Vegetationsversuche im Sommer 1863. *Landw. Versuchsst.*, 6: 355-359. 1864.
135. RUSSELL, SIR E. J. Soil Conditions and Plant Growth. 6th ed. vi + 636 p. *London*, 1932.
136. SABLON, LÉCLERC DU. Traité de Physiologie Végétale et Agricole. *Paris*, 1911.
137. SAUBOURN, TH. DE. Ueber die Ernährung der Pflanzen. *Liebig's Annalen*, 42: 275-291. 1842.
138. SCHATTELMANN. Mémoire sur quelques expériences relatives à l'emploi de l'engrais liquide et des sels ammoniacaux, etc. *Ann. Chim. et Phys.*, 11: 236-242. 1844.
139. SCHREINER, O., and J. J. SKINNER. Ratio of phosphate, nitrate and potassium on absorption and growth. *Bot. Gaz.*, 50: 1-30. 1910.
140. ———, ——— Nitrogenous soil constituents and their bearing on soil fertility. *U. S. Dept. Agric. Bur. Soils Bull.* 87. 1917.
141. SCHULOW, I. Zur Frage über das Löslichwerden der Phosphate unter dem Einfluss physiologisch-saurer Salze. *Jour. Exp. Landw. (Russia)*, 3: 711-719. (From *Biedermann's Centrbl.*, 33: 79-80. 1904.)
142. ——— Sterile Kulturen einer höheren Pflanze. Assimilation von Ammoniak- und Nitrat-Stickstoff. *Jour. Exp. Landw. (Russia)*, 13: 200-206. 1912.
143. ——— Versuche mit sterilen Kulturen höherer Pflanzen. *Ber. deutsch. bot. Ges.*, 18: 36-42. 1900.
144. SHIVE, J. W. The influence of various salts on the growth of soybeans. *Soil Sci.*, 1: 163-170. 1916.
145. ——— and W. H. MARTIN. A comparison of salt requirements for young and for mature buckwheat plants in water cultures and sand cultures. *Amer. Jour. Bot.*, 5: 186-191. 1918.
146. ——— and A. L. STAHL. Constant rates of continuous solution renewal for plants in water cultures. *Bot. Gaz.*, 84: 317-323. 1927.
147. STEWART, G. R., E. C. THOMAS, and J. HORNER. The comparative growth of pineapple plants with ammonia and nitrate nitrogen. *Soil Sci.*, 20: 227-242. 1925.
148. STOHMANN, F. A. Vegetationsversuche in wässrigen Lösungen. *Landw. Versuchsst.*, 6: 347-355. 1864.
149. THATCHER, R. W. The Chemistry of Plant Life. xi + 268 p. *New York*, 1921.

150. TINDJENS, V. A., and W. R. ROBBINS. The use of ammonia and nitrate nitrogen by certain crop plants. *New Jersey Agric. Exp. Sta. Bull.* 526. 1931.
151. TIMIRIAZOFF, C. A. The Life of the Plant. (Transl. by Anna Cherometeff.) London, 1912.
152. TORREY, R. E. General Botany for Colleges. xxii + 449 p. New York, 1932.
153. TOTTINGHAM, W. E. A quantitative chemical and physiological study of nutrient solutions for plant cultures. *Physiol. Res.*, 1: 133-245. 1914.
154. TREBOUX, O. Zur Stickstoffernährung der grünen Pflanze. *Ber. deutsch. bot. Ges.*, 22: 570-572. 1904.
155. TRELEASE, S. F., and B. E. LIVINGSTON. Apparatus to secure constant renewal of nutrient solutions. *Science*, 55: 486. 1922.
156. ——— and F. P. PAULINO. The effect on the growth of rice of the addition of ammonium and nitrate salts to soil cultures. *Philippine Agric.*, 13: 293-313. 1920.
157. ——— and HELEN M. TRELEASE. Toxicity and antagonism in salt solutions as indicated by growth. *Bull. Torrey Bot. Club*, 53: 137-156. 1926.
158. VILLE, G. Notes sur l'assimilation de l'azote de l'air, par les plantes, et sur l'influence qu'exerce l'ammoniaque dans la végétation. *Compt. Rend. Acad. Sci. (Paris)*, 31: 578-580. *Ibid.*, 35: 650-654. 1852.
159. VILLE, G. Experimentelle Untersuchungen ueber das Pflanzenwachstum. *Biedermanns Centrbl. Agric. Chem.*, 8: 379-388. 1875.
160. VRIES, O. DE. (Observations on the combustion of tobacco.) *Proefstat. Vorstenland. Tabak (Dutch E. Indies) Meded.*, 22: 5-23. 1916. (From *Exp. Sta. Rec.*, 38: 139. 1918.)
161. WAGNER, P. Vegetationsversuche ueber die Stickstoffernährung der Pflanzen. *Landw. Versuchsst.*, 11: 287-299. 1869.
162. ——— (Fertilizer experiments with tobacco.) *Arb. deutsch. Landw. Ges.*, 138: 99. 1908. (From *Exp. Sta. Rec.*, 20: 748-749. 1908-09.)
163. WILLIS, L. C., and J. O. CARRERO. Influence of some nitrogenous fertilizers on the development of chlorosis in rice. *Jour. Agric. Res.*, 24: 621-640. 1923.
164. WOLKOFF, M. I. Effect of ammonium sulfate in nutrient solution on the growth of soybeans in sand cultures. *Soil Sci.*, 5: 123-150. 1918.
165. ZALESKI, W., and N. TUTORSKI. Über die künstliche Ernährung der Samenkneime. *Biochem. Zeitschr.*, 43: 7-9. 1912.
166. ZINZADZE, SCH. R. Neue normale Nährlösungen mit stabiler Reaktion (pH) während der Vegetationsperiode. *Landw. Versuchsst.*, 105: 267-332. 1927.





THE PREMAXILLA IN THE PRIMATES

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I. INTRODUCTION

THE present study owes its origin to the endeavor to determine whether or not the alleged early obliteration of the facial division between the maxillary and premaxillary bones in man may be regarded, as Professor Wood Jones has repeatedly affirmed, as "a definite human specific character" (100).

This endeavor has led so far afield that it may truthfully be said that the answer to this question now constitutes the least important part of this study. For, as we shall see, whether the processes of development which result in the facial obliteration or obscuration of the premaxilla in man are peculiar to him alone, or not, is a matter of no very great consequence in view of the remarkable series of morphological facts brought to light in this study, such, for example, as the peculiar form and relations of the premaxilla which, in man, have for the most part been unknown, and the nature of the involution which this bone has in man undergone and is still in process of undergoing. It will be shown that in the Primates without exception the form of the premaxilla is entirely dependent upon the functions it subserves, and that its form varies exactly in proportion as its functions vary. Finally, as a result of our observations certain biologic principles, seldom so clearly illustrated, will receive yet another demonstration of their validity. But this is to anticipate.

Ever since the publication of Vesalius' immortal *De Humani Corporis Fabrica* in the year 1543, the premaxillary bone has

formed the subject of much contention, some of it extraordinarily vituperative, and some of it characterised by a vigor of expression which was apparently inversely proportional to the writer's understanding of his subject. The alleged absence of the premaxilla upon the facial aspect of the human skull was for long regarded by the earlier writers as one of the facts most significantly demonstrative of man's wide separation from the sub-human Primates and the remainder of the Mammals, and indeed, this belief is not yet quite exhausted, for it is still to be found, in a somewhat modified form and based upon a vastly more substantial series of observations than was available to the earlier students of the subject, in the writings of Professor Wood Jones, (85), (93), (100). To the history, however, of this subject, which forms one of the most interesting chapters of comparative anatomy, we will advert in the succeeding section of this study.

According to the viewpoint examined in the present work it is held that in the Primates, with the exception of man, the premaxilla may be observed upon the facial aspect of the skull suturally quite distinctly separated from the maxilla in almost all sub-adult as well as in many adult individuals. In late foetal and post-natal man no trace of the separation of this bone from the maxilla upon the face is to be observed, although the palatine portion of the premaxilla may be distinctly observed in the majority of infant crania, and may be encountered in some 26.0 per cent of adult crania. The latter

division of the premaxilla has been adequately dealt with by numerous investigators, and will therefore not be treated of quantitatively in the following pages. All Mammals, with the exception of the bats and certain edentates, possess premaxillary bones (102), but man alone of all the Mammals, so it is claimed, shows no trace of this bone upon the facial aspect of the skull either at birth or ever afterwards. The assertion is not that man does not possess a premaxilla, the presence of which has long been known in foetal and post-natal man, but that its identity as a distinct element upon the face is lost so early in development (about the end of the third foetal month) that this premature annulment of its status as an independent element must be regarded as a human specific character, since in the Primates inferior to man, and the Mammals in general, this bone remains facially distinctly separate from the maxilla until the attainment of a relatively advanced age.

Wood Jones' View

This view of the matter may be considered as it is expressed by its original proponent, Professor Wood Jones, for his views in this connection constitute the text to which this paper may, among other things, rightly be regarded as forming the critical commentary. I hope I need not say that in citing Professor Wood Jones' statements in this connection I have not the slightest wish to be polemical. Professor Wood Jones has of late years raised a large variety of interesting questions bearing upon the evolution of man—these questions require a definite answer, and in this study I wish merely to make one such answer to at least one of the most interesting questions he has raised. In his latest work (100) Professor Wood Jones writes,

... a definite human specific character is determined by the early loss of the facial identity of this element [the premaxilla] of the upper jaw. The human distinctions in regard to the premaxilla have often been minimized by comparative anatomists owing to misconceptions concerning the actual conditions present in *Homo*. It is easy to understand how Galen, familiar with the anatomy of Monkeys, but a stranger to the details of human structure, assumed that in man, as in Monkeys, there were two separate bones in the skeleton of the face, bearing the incisor teeth, and marked off from the maxillary bones on the face, as well as on the palate, by suture lines such as are present in the Monkeys. When in 1543, Vesalius affirmed that this facial suture line did not exist in man, although the limits of the os incisivum were at times distinct enough on the palate, his statement was regarded merely as an indication that the human skulls he had examined had departed from the standard of Galen's day.

Camper was probably the first to claim that the absence of the facial separation of this element was a distinctly human characteristic. Following him, Blumenbach, who named the bone in question the intermaxillary, recognized its human distinction, and Sir William Lawrence went further, and regarded the premaxillary element as altogether absent in man, and emphasized the fact that in this character man was separated from all other animals.

After Lawrence's day the question of the premaxillary bone became largely a debate as to its presence or absence as an element in the human skeleton, and its peculiarities as to early fusion on the face were somewhat neglected. Vicq D'Azyr, Goethe, Nesbitt, Leuckart, and many others showed what Vesalius had already affirmed, that the bone was in reality present in man, but that it was not marked off from the maxilla by suture lines after the sixth month of foetal life. Hamy and others devoted considerable attention to the question of the premaxillary-maxillary suture on the palate, and Albrecht, Warinski, Gils, Menard, and many others have carried the work on the palatal portion, and its ossification to great lengths. Owing to the work of these investigators there is now agreement as to the facts that the premaxilla remains separate from the maxilla on the human palate until the fourth or fifth month of foetal life; that by the sixth month, as a rule, the suture between it and the maxilla is closed, that in prognathous skulls, and in cases of rickets and hydrocephalus the closure of the suture may be delayed, and that in abnormal cases traces of the suture may even be visible in adult skulls. All this is a universally recognized anatomical fact concerning the formation of the palate; it does not, however, affect

the question of the fate of the premaxilla on the facial aspect of the skull. Regarding this point there has been much erroneous teaching. Ten years ago I drew attention to the fact that "when the human embryo is no more than 19 mm. long—that is about ten times the diameter of an ordinary pin's head—the premaxilla is losing its identity in the cartilage of the maxilla, and when the embryo is another 5 mm. longer it has ceased to exist as a separate entity on the face. The process by which the facial portion of the premaxilla becomes lost as a separate element is a complicated one, and it involves far more than the mere loss of the superficial suture line, for the whole method of growth of this part of the face is involved. The human premaxilla is lost in, and becomes overgrown by, the facial portion of the maxilla, but it still shows its independence of the maxilla, not only upon the palate, but within the nasal chambers." These statements were made as a result of an examination with Professor Fawcett of his unmatched material of developing chondrocrania in 1914, and they were made as a direct refutation of the erroneous teaching that has been put forward concerning the actual state of affairs present in *Homo*. In 1892 the distinguished author of the Cartwright Lectures laid it down as an anatomical truth that the human premaxilla is sometimes partially, and sometimes, but more rarely, wholly, isolated from the maxilla on the face. It was also affirmed that the junction of the two elements was effected late in certain races, such as Australians, New Caledonians, and Greenlanders. . . .

The anatomical fact of the early loss of identity of the human facial portion of the premaxilla is not to be denied. Nor must its importance be overlooked. This obliteration of the facial premaxilla is a distinguishing character of man as a species; it would be used by the systematist as a specific diagnostic feature of *Homo*.

Now we have seen in Chapter III that although rigid interpretations of the Biogenic Law are no longer possible, nevertheless, there is an order in the acquirement of ontogenetic characters, and specific characters, being mostly acquired characters, are determined late in ontogeny. We know that there are many factors that produce upsets in the sequence of ontogenetic development, but allowing for all these, it is impossible to avoid attaching importance to this fact of the merging of the facial portion of the premaxilla in the matrix of the maxilla in the human embryo at so early a period as the 24 mm. stage. The more importance must be attached to it since, as Zittel remarks, "It is an unimportant character" (94). Being an unimportant character there appears to be no reason for its early translation to this early stage

on any grounds of expediency in development. It is its very unimportance that renders it probable that its early ontogenetic accomplishment is guarantee of its early phylogenetic acquirement, and since it is a human specific diagnostic character such a finding is of considerable interest.

Is the obliteration of the premaxillary suture peculiar to man?

There is much in all these statements that is true; they require, however, a detailed examination, for apart from Wood Jones' own observations an exhaustive study of the literature dealing with this subject reveals the fact that up to the present time the facial aspect of the premaxilla in the Primates has been given comparatively little attention by previous investigators, and that where this attention has been bestowed the number of cases examined has been extremely limited. Conclusions based upon the examination of an inadequate amount and variety of material must be regarded with the greatest caution. Wood Jones has further constantly maintained that since "The premaxilla is never marked off by suture lines from the maxilla on the face . . . how far up the sides of the narial aperture the premaxillary element extends is therefore unknown in *Homo*," (100); it will be necessary to inquire into this matter, as well as into Professor Wood Jones' statements relating to the form and articulations of the premaxilla common in New World and Old World Monkeys. An important task will be to determine the period of closure, or the stage of development at or during which, the premaxilla loses its independence by uniting with the maxilla upon the face in the various genera of sub-human Primates, the purpose being to discover whether there exists a trend of significance, with respect to the period of closure of the premaxillary suture in any of the Primates, which may in some way be connected with the early obliteration of the

same suture in pre-natal man. Finally, when these observations have been completed and the data recorded and analysed, the general aetiology of the differences observed, such as the late persistence of the premaxillary suture upon the facial aspect of the skull in some Primates and its early obliteration in others, will be discussed.

If it can be shown that there exists a very definite tendency for the premaxillary suture to undergo obliteration fairly early in the development of some groups of sub-human Primates, and that in such Primates certain conditions are to be found which are not present in other members of the Order, something will have been achieved which may help us to understand that the existing differences, real as they are, between man and certain Primates with respect to the loss of identity of the premaxilla, are, in fact, demonstrative of a close rather than of a distant relationship between man and such Primates.

In the succeeding section some space has been devoted to a consideration of the work of previous investigators relating to the subject of the premaxilla, from the earliest to the latest times. A number of highly important studies have been rescued from an obscurity as profound as it has been altogether unmerited, and by their means certain most germane facts brought to light.

The literature dealing with the premaxilla is vast, and whilst more than two hundred separate works have been read in the preparation of this study, such only as have had a direct or fairly direct bearing upon the comparative anatomy of the subject have been noticed here. The Bibliography appended to this study may be supplemented by those given in the works of Hamy (46), Frison (68), and Franz (115).

What may seem to some a disproportionate amount of space has been devoted

to the writings of the earlier anatomists who had in any way concerned themselves with the premaxilla. This has been done in order to put an end to the reigning confusion which exists with respect to what a particular authority actually wrote in connection with the premaxilla. Also, it was thought that an historical conspectus of the subject, based upon the words of each authority, would help to establish more accurately than is at present the case, where honor is properly due for discoveries generally credited to those who neither made nor even showed acquaintance with them. In the majority of cases authorities are quoted from the original first edition of their work; in a few cases it has unfortunately been impossible to obtain the original edition of the work referred to, so that a later or translated edition has had to be relied upon,—such works are noted in the proper place.

For the opportunity to examine most of the rare works mentioned in this study, and for the loan of many of them, I am deeply indebted to the New York Academy of Medicine and its Librarians. To the Library of the American Museum of Natural History, New York, I am obliged for the loan of the volumes containing the papers by Vicq D'Azyr and Leidy which have been used in this study, and for the use of many of the Journals referred to. To Miss Helen Bayne, and to her assistant Mr. Hyman Gross of the Library of Bellevue Hospital Medical College, New York, I am greatly indebted for help in procuring the various loan volumes.

To Professors Wingate Todd and W. M. Krogman, of the Laboratory of Anatomy, Western Reserve University, Cleveland, my best thanks are due for reading this paper in manuscript and for drawing my attention to a number of studies which I had completely overlooked.

The material reported upon in this study consists of some 9947 post-natal Primate crania, ranging in age from birth to adult life; of these crania 5277 are sub-human and 4670 human. In addition some 16 human foetuses, both white and negro, have been examined. Skulls examined for other purposes and mentioned hereafter are not included in this total of 9963 specimens. The detailed description of this material will be found in the pages which follow.

To the following gentlemen grateful thanks are due for permission to examine the collections of crania in their charge, namely:

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2. LITERATURE

Vesalius

The critical and controversial literature dealing with the premaxilla begins with the publication of Vesalius' *De Humani Corporis Fabrica* in the year 1543 (5). In this work Galen's anatomy is subjected to a careful examination and at almost every point is found wanting. Perhaps the severest criticism which Vesalius has to make is uttered in the section of Osteology dealing with the *Superior Maxilla*. It will be recalled that before the advent and

appearance of Vesalius' great work, mediæval anatomy was dominated almost entirely by the teaching of the second Century Greek, Claudius (as he has been mis-named) Galen, (A.D. 131-201), one of the very greatest and most creative of biologists of all time, as he has rightly been called (95). His writings were voluminous and encyclopaedic, touching upon every phase of medicine and its practice. For fourteen centuries the *Corpus* of the Galenic opera constituted the supreme authority to which European medicine paid religious tribute. As a descriptive anatomist Galen will always occupy a very high place, even though many of his descriptions were inaccurate, for Galen's acquaintance with the intimate structure of the human body was a fugitive one, being based for the most part upon the dissection of monkeys, dogs, and swine. Galen's osteology is clearly simian, so that when he describes premaxillary suture lines upon the facial aspect of the skull of man he is clearly projecting a condition of simian origin which he undoubtedly did not observe in the human skull. It is interesting to note in passing that Galen was actually not the first anatomist erroneously to describe the premaxillary suture upon the facial aspect of the human skull; the priority belongs to Rufus of Ephesus (A.D. 98-117) who, in his little work on anatomy, after giving an accurate description of the zygomaxillary suture, makes the observation that *duas alias quas cerni queant in malis*, two other sutures, scarcely visible, are present on both sides of the face (on either side of the nasal aperture), here undoubtedly referring to the premaxillary sutures. (1). Vesalius, in his lengthy section on the *Superior Maxilla* notices the exomesognathic portion of the premaxillary suture upon the palate of man but absolutely denies the existence of premaxillary suture lines upon the facial

aspect of the human skull as described by Galen. His account of the form and structure of the maxilla is masterly, and his criticism of the Galenic description telling. The relevant passages are far too lengthy to transcribe here, but their forceful cogency leaves one very definitely with the impression of Menenius that "the most sovereign prescription in Galen is but empiricistic." (*Coriolanus*, Act II, Sc. II). Following the appearance of his great work Vesalius was immediately fallen upon and attacked for his treasonable conduct against the traditional teaching of Galen. Tyson 1699 (15) over one hundred and fifty years later gives a good account of the controversy which followed, it is here reproduced in his own words. Tyson commences by quoting Galen as saying that

One ought to know the Structure of all the Bones either in a Humane Body, or in an Ape's, 'tis best in both; and then to go to the Anatomy of the Muscles

What Galen advised, no doubt he practised himself, and observed both. But *Andreas Vesalius* will not allow him this. For in his great and excellent Book *De Corporis Humani Fabrica*, he all along tells us, that Galen gives us rather the *Anatomy of Apes* than of a *Man*. And in his *Epistola ad Joachimum Roelants de Radice Chymae* (6), his chief Design is to prove, that Galen never dissected a *Humane Body*; and that he is often mistaken in the History of the Parts, as also in their Uses, and that his Reasonings are frequently unconvulsive.

Upon the coming out of *Vesalius* his first Book, he was warmly opposed by *Jacobus Sylvius* a Physician at *Paris*, who had formerly been *Vesalius* his Master in *Anatomy*; in a treatise stiled *Depulsio Vesalii Cusudam Calumniarum in Hippocratis & Galeni Rem Anatomica* (7). This was answered not long after by *Renatus Henarus*, who published another Treatise, viz. *Adversus Jacobs Sylvii Depulsioem Anatomiarum Calumnias pro Andrea Vesalio Apologia*. Sylvius afterwards procures a Disciple of his to write against *Vesalius*, who puts out, but unsuccessfully, *Apologia pro Galeno contra Andream Vesalum Bruxellensem, Franciscus Putio Madico Vercellensis Auctore*. A scholar of *Vesalius*, *Gabriel Camerius*, makes a reply to *Putius* in his *Apologia Franciscus Putius pro Galeno in Anatomie examen*. Upon *Vesalius* his leaving *Rome*, a Disciple

of his, *Realdus Columbus*, grew very famous for *Anatomy*, but ungrateful to his Master, as *Vesalius* complains in his Book *De Radice Chymae*, and his *Examen Observationum Falloppii*. But *Gabriel Falloppius* was always kinder to him, and mentions him with the greatest Honour, and calls him *Divine*; tho' in several things he dissents from him, which occasioned *Vesalius* his putting out his *Observationum Falloppii Examen* (10).

Seven years before the appearance of *Vesalius*' work Sylvius, following the Galenic tradition, had stated that he had observed the premaxillary suture upon the facial aspect of the skull in many human adult skulls (4). When then *Vesalius* 'presumed' to question the validity of the same statements in Galen, Sylvius, upon whose head the cap fitted only too neatly, chose to consider the criticism as a personal affront put upon him by *Vesalius*. He therefore delivered himself in 1551 of an attack upon *Vesalius* (7) so vitriolic that it probably remains unique and unparalleled in the annals of scientific literature. Of *Vesalius* himself Sylvius is pleased to say, in no round terms, that he is a madman as well as a liar. Whilst of the premaxilla he is content to say that undoubtedly *Vesalius* is wrong in his description of it, that is, in denying the existence of the facial premaxillary suture lines in the skull of the human species, and even though they may no longer be present upon the face of contemporary man there can be no doubt that the sutures were present in the skull of man in Galen's day!

Such a statement may today strike us as somewhat ludicrous, but in fairness to Sylvius, it should be remembered that Mediaeval Dogma, assisted by the teaching of the Church, laid it down as a necessary truth that man had departed considerably from the standards both of virtue and structure which had originally characterized Adam and Eve. The rate of evolution was speeded up or slowed down at the convenience of the Church, and so long as their statements could not be interpreted as conflicting with the received Dogma lay thinkers were at perfect liberty

to juggle that rate howsoever they pleased. Sylvius, among others, did not fail to take advantage of that liberty to heap reproaches and contumely upon the head of one whose heresy was that he had dared to think for himself and challenge the superstitions and the idols of his erstwhile masters.

The subsequent history of the premaxilla may be followed largely through the works of the seventeenth, eighteenth, and nineteenth Century anatomists.

Columbus, Fallopius

In the sixteenth Century, immediately following Vesalius, Columbus 1559 (8) and Fallopius 1561 (9) accurately described the palatal component of the premaxillary suture, but neither of them had anything to say of its homology with the same suture in lower animals. Columbus notes that the suture *ad utrumque* is present on both sides, *caninum dentem terminatam*, and terminates at the canine teeth, *quae in pueris conspicua est*, that it is conspicuous in the young, *in adultis autem sic aboletur*, and that in the adult, on the other hand, it is obliterated, *ut nullum sui vestigium relinquat*, not a vestige of it remaining. Fallopius merely notes that the suture in question is a transverse slit near the incisive foramen, "Nam reperio hanc divisionem, vel rimam potius esse, quam suturam, cum os ab osse non separet, neque in exterioribus appareat, vel cum os cum osse non conjungat; quod suturarum munus est si sub articulo debent." "... a division or fissure rather than a suture, since it does not separate one bone from the other, nor does it appear exteriorly, nor join two bones, which is the function of sutures." Similar views with respect to the nature of this suture have been independently expressed by Kölliker (53) in the nineteenth and by Fawcett (78) and Jarner (81) in the twentieth Century.

Seventeenth century anatomists

In the seventeenth Century both Ingrassias 1603 (11) and Riolan 1610 (12)

range themselves with Vesalius against Galen, though Spigel 1626 (13) and Eysen 1699 (14), who give a description of the incisive suture, make no mention of the premaxillary suture. Towards the close of the century Tyson 1699 (15) in describing his *Orang-Outang*, which in reality was a chimpanzee, the skeleton of which is still preserved in The British Museum of Natural History, London, writes that "The suture of the *Palate* in our *Pygmie* was just the same as in *Man*. In a *Monkey* I observed that *peculiar suture Riolan* mentions, but did not find it in the *Pygmie*, only in the *Palate* of the *Pygmie* I observed a Suture, not from the *Dens Caninus*, as was in the *Monkey*, but from the second of the *Dentes Incisores*."

Nesbitt, Albinus

In the eighteenth Century the first work of importance with respect to the premaxilla is Robert Nesbitt's 1736 (16) cursory description of the completely isolated premaxilla in a human foetus entering upon its fourth month. All attempts to secure a copy of Nesbitt's volume have met with failure, but according to Hamy (44) the premaxillary sutures could be distinctly seen in Nesbitt's specimen upon the facial aspect of the skull. It would appear then that it is to Nesbitt that the credit belongs for having given the first description of the completely isolated premaxilla in a human skull.

Immediately following Nesbitt, Albinus 1737 (17) described and figured the endo-facial portion of the premaxillary suture which in his specimen, a young individual, extended as far as the ridge of the inferior nasal concha.

Blumenbach

Blumenbach in the thesis which he submitted for the degree of Doctor of Medicine in 1776 (19), a work which has often been said to have laid the foundations of

modern physical anthropology, makes the following statements concerning the premaxilla:

"peculiare illud os, cui dentes incisores insident, maximam attentionem meretur. Es nempe homo caret, cum omnibus simiis plurimisque aliis mammalibus datum sit. Dubitabum quidem num quoque oran utan eodem instructus esset; cum nec Tysoniana nec Daubentoniana cranii eius icones curate satis essent, ut suturae probe distingui possent, neque Anglus auctor praecise satis de eo loqueretur: soluit autem nodum EXC. FR. GABR. SULZER, qui CAMPERUM virum eiusmodi animalia incidisse, idemque os in iisdem reperisse benivole mihi scripsit." "That particular bone in which the incisors are lodged deserves particular attention. This man is without, although all the apes and most of the mammals possess it. I doubted whether the orang-utan was equipped with this bone, since in the figures of Tyson and Daubenton (18) the skulls were not drawn in such a way as to render the sutures distinguishable: nor did the English author speak precisely about it: but his Exc. Fr. Gabr. Sulzer has settled the point, for he kindly writes me word that Camper, a great authority, has dissected animals of this kind and found this bone in them."

It is clear then that in this his earliest reference to the subject Blumenbach denied the existence of the premaxillary bone in the human skull.

Camper

It is often stated that Camper considered the absence of suture lines, that is, premaxillary suture lines, upon the facial aspect of the human skull as a distinctly human characteristic indicative of man's wide separation from the other mammals. A careful examination of Camper's complete works, together with Goethe's correspondence with Camper upon the subject (27) has failed to reveal as much as a single word that could be interpreted so. The work usually referred to as containing this statement (20) was first published in December 1778 and was concerned with the anatomy of various orang-utans. The only reference to the premaxilla in this work is as follows (the quotation is from

the collected edition of the shorter works published in German translation from the Latin in 1784): Camper writes,

dass Oberbackenbein in zwei zertheilt, so das von der Nasenhöhle bis zwischen dem Hunds—und Schneidezahn eine Nalt lauft, wie bei allen Affen, Hunden, Katzen, Löwen und allen wiederkauenden Thieren, obschon diese oben keine Schneidezähne haben. Dieser vordere Theil enthält im Orang von beiden Seiten die zwei obern Schneidezähne so wie es *Galen* sehr deutlich aus den Affen beschrieben hat.

Diese Eigenschaft allein bestimmt dem Orang seinem Platz unter den vierfüßigen Thieren. Ich besitze in meiner Sammlung Köpfe von Negern, Hottentoten, Kalmucken, Molucken, Chinesen, und von einer grossen Anzahl neu—und ungeborner europaischen Kinder, ohne jemals einen einzigen Beweis dieser Trennung darinn gesehen zu haben.

There is no statement here, nor is there in his correspondence with Goethe on the subject, to the effect that man is unique in the absence of a premaxillary suture and therefore unlike all other mammals. Camper merely states that he has never observed this suture in man, having previously said that its presence in the orang-utan determines the latter's place to be among the quadrupeds; all of which is very different from what has customarily been attributed to him as having stated. Goethe, however, always believed that Camper obstinately refused to believe in the existence of this suture and therefore never saw it, but this may or may not have been the reason for Camper's shortsightedness.

Vicq D'Azyr

In 1780 (21) Vicq D'Azyr published a short paper, a study of three Primates, in which, among other things, he gave a description of the premaxilla in man and for the first time pointed out its *structural equivalence* to the same bone in other mammals. This paper is of unique importance since its description of the premaxilla in man, limited though it is, is the first to have been made upon a comparative basis.

Vicq D'Azyr's identification of this structure in man with the premaxilla of lower mammals proves that it is to him and not to Goethe, who published his paper some six years later, that the credit for the 'discovery' belongs. It is quite possible that Goethe was acquainted with Vicq D'Azyr's study, but if he was, he makes no mention of it in his own paper. Vicq D'Azyr's remarks on the subject of the premaxilla are of such classical importance, and the figures that accompany them of such interest, that it has been considered desirable to reproduce them here in order to render them more generally accessible. Vicq D'Azyr writes:

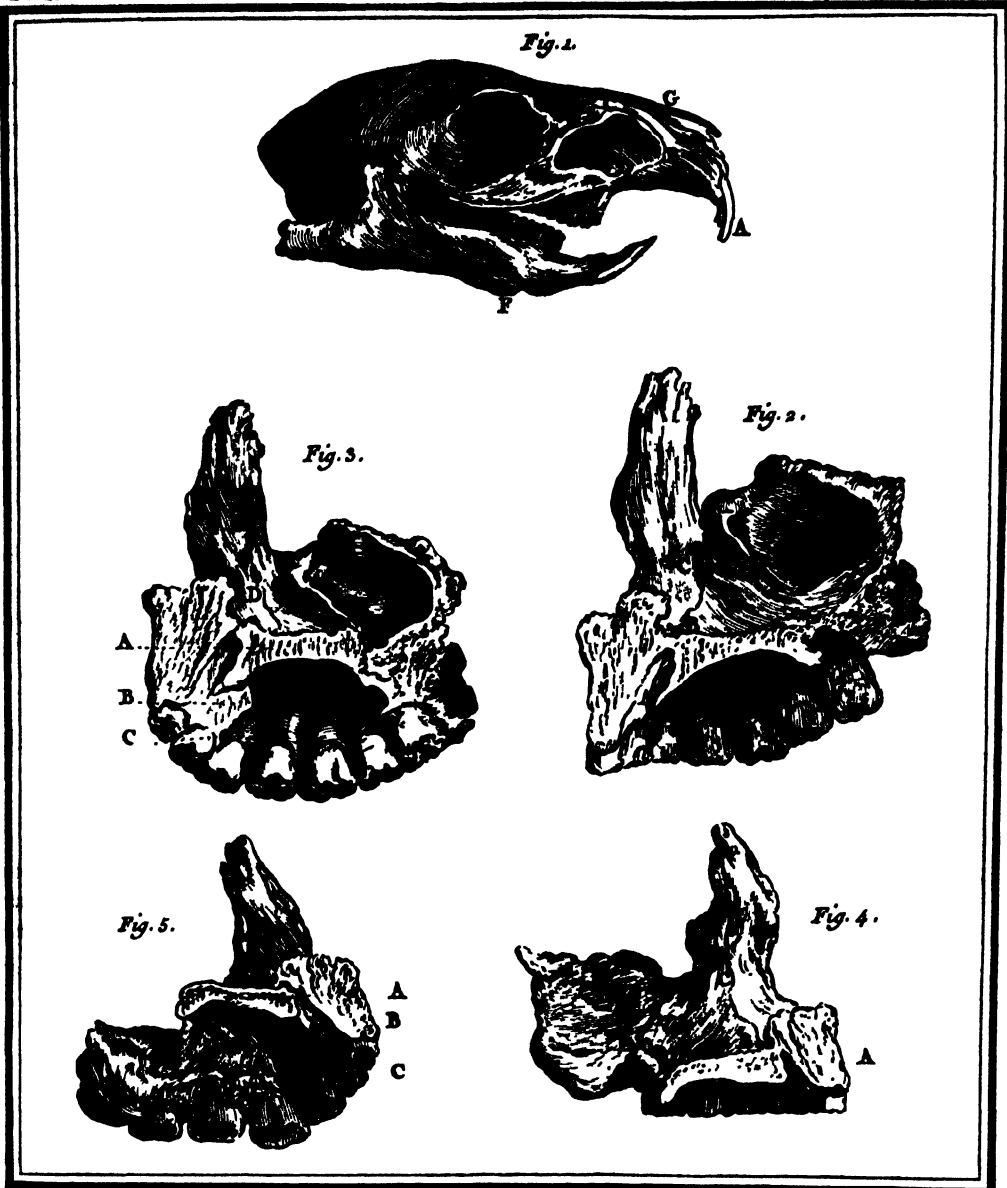
L'existence de deux trous incisifs dans la fosse buccale du mandrill, n'a rien qui doive surprendre, on le trouve dans les fissipèdes, tels que le chien, le chat; dans les bisulques, tels que le bœuf & le mouton; dans les solipèdes, tel que le cheval. En portant plus loin ses recherches, on observe, même dans le squelette des oiseaux, que la pièce mobile de la mandibule supérieure, ayant deux ouvertures latérales, établit entre la cavité du nez & celle de la bouche, une communication très-utile sans doute, soit au sens d'odorat, soit à celui du goût, soit à tous les deux ensemble, puisque cette conformation se trouve dans plusieurs classes d'animaux; c'est dans les bisulques & dans les solipèdes que ces trous ont le plus d'étendue, il y a même un os à double branche, spécialement (s) (Planche II, fig. 1 & 2, AB.) destiné à les former, & à soutenir les dents incisives lorsque la mâchoire supérieure en est pourvue; cet os, dans le cheval (p), dans le bœuf & dans le mouton (q), s'articule avec les os du nez & avec l'os maxillaire antérieur; il porte dans l'ouvrage de M. Vitet, le nom d'*os maxillaire inférieur* (r) (r Tome 1, p. 53). Le lapin, & en général les quadrupèdes qui ont quatre dents incisives, dont deux sous isolées à chaque mâchoire, montrent une disposition analogue; le deux incisive de la mâchoire antérieure sont implantées dans un os particulier qui termine la face, & forme les deux trous incisifs (r); (s. Voy. pl. III, fig. 1, A les deux dents incisives supérieures du lapin. B. l'os qui les soutient. CD la suture courbe qui les unit avec l'os maxillaire antérieure); moins la face est prolongée, moins aussi ces ouvertures sont amples, dans le chat elles sont étroites, & dans les singes cynocéphales, elles sont plus grande que dans ceux qui ont la face plus courtel l'homme étant de tous les animaux celui dans lequel:

cette région l'est le plus, les trous incisifs doivent se rétrécir en même proportion, leur ouverture osseuse, double du côté du nez, est simple du côté de la bouche (r); (t Quoique cette ouverture osseuse soit simple & unique du côté de la bouche, il n'en est pas moins vrai que les Anatomistes exacts y démontrent deux conduits, ce qui établit sous ce point de vue, une grande analogie entre la structure de l'homme & celle des animaux); mais il est important de remarquer que l'os maxillaire supérieure de l'homme présente souvent, sur-tout dans les jeunes sujets, derrière les trous incisifs & le long de la branche montante, une fêlure qui sépare la portion sur laquelle les dents incisives sont appuyées, d'avec le reste de l'os (u): (u Pl. III, fig. 4, os maxillaire humaine d'un jeune sujet: A partie du trou incisif dans la bouche; B une fêlure dont il s'agit, qui s'étend le long de la branche montante. . . . Fig. 5, même os, vu en-dessous, du côté de la voûte palatine; A la partie la plus élevée du trou incisif; A B C suite de la fêlure susdite, qui s'étend jusqu'à la seconde dent incisive.); on ne peut s'empêcher de voir un rapport singulier & inattendu entre la structure de la portion osseuse qui, dans plusieurs quadrupèdes, sert à soutenir les dents incisives, & celle qui, dans les enfants au moins, a les mêmes usages (x). (x Voy. Anatomie de M. Sabatier, tome 1, p. 55). Il en est au reste de cet os comme de tous ceux qui composent la tête, les traces de sa séparation s'effacent avec l'âge, je l'ai cependant rencontré dans quelques adultes (y); (Voy. pl. III, fig. 2, A partie du trou incisif; B C la fêlure le long de la branche montante, dans l'os maxillaire supérieure d'un adulte. Fig. 3, le même os d'un adulte, vu du côté de la face palatine; A la partie la plus élevée du trou incisif, B C le prolongement de la fêlure du côté du nez & la branche montante.); l'Anatomie comparée nous apprend donc pourquoi cette fêlure existe, & elle nous montre aussi qu'elle est l'ouverture respectif des trous incisifs dans les différentes classes d'animaux.

These statements together with his figures prove beyond a shadow of doubt that Vicq D'Azyr was already acquainted, as early as 1780, with the form of the premaxillary bone in man as well as with its morphological significance.

Goethe

Goethe in his study of 1786 (22) described the inferior portion of the endo-facial premaxillary suture, which, in certain cases in man he observed, as others



Eschsch. del.

J. le Gros. sculp.

FIG. 1. THE FOLLOWING IS VICQ D'AZYR'S LEGEND ACCOMPANYING HIS PLATE III REFERRED TO IN HIS TEXT

Fig. 1. Skull of a rabbit. A. The two superior incisor teeth. B. The bone in which they are lodged. C, D. The suture which unites this bone with the neighboring bone. G. The nasal bone. E. The orbit. F. The mandible.

Fig. 2. Human maxilla of advanced age, viewed from the internal or medial aspect. A. Incisive foramen. B, C. The suture which extends along the ascending process of the maxilla. D. The maxillary sinus.

Fig. 3. The same bone viewed from the palatine aspect. A. Commencement of the incisive foramen. B, C. Line which shows the course of the suture; it extends up to the second incisor tooth of this bone. E. The maxillary sinus.

Fig. 4. The maxilla of a foetus, viewed from the internal or medial aspect. A. The incisive foramen. B, C. The suture which is prolonged upon the ascending maxillary process. D. Groove, called *palatine*, for the reception of the anterior border of the ascending process of the palate bone.

Fig. 5. The same bone, viewed from the palatine aspect. A. Entrance of the nasal foramen. B, C. Prolongation of the suture towards the alveolar border up to the second incisor tooth.

had already before him, to extend superiorly as far as the vicinity of the ridge for the inferior nasal concha. Referring to Vesalius' description of the premaxillary suture upon the palatine aspect of the skull and commenting upon this and Vesalius' figure of the suture in the dog and in man, Goethe writes,

Denn jene erste Suture hatte schon Vesalius bemerkt. Die zweite Suture, die sich in Nasengründe zeigt, aus den *Canalis naso-palatini* heraustritt und bis in die Gegend der *Concha inferioris* verfolgt werden kann, hat er nicht bemerkt. Hingegen finden sich beide in der grossen Osteologie des Albinus bezeichnet: er nennt sie *suturas maxillae superiori proprias*.

Am Sichtbarsten fällt des Os intermaxillare von Menschen bei n. 1 in die Augen. Man sieht ganz deutlich die Suture, die das Os intermaxillare von der Apophysi palatina maxillae superioris trennt. Sie kommt aus den *Canalis incisivi* heraus, deren untere Oeffnung in ein gemeinschaftliches Loch zusammenfliesst, das den Namen des *Foraminis incisivi* oder *palatini anterioris* oder *gustativi* führt, und verliert sich zwischen dem Hunds- und zweiten Schneidezahn.

Bei n. 2 ist es schon etwas schwerer zu bemerken, wie dieselbe Suture sich in dem Nasengrunde zeigt. Es ist diese Zeichnung nicht die glücklichste; allein an dem meisten Schädeln, besonders jungern, kann man solche sehr deutlich sehen.

Es wird also wohl kein Zweifel übrig bleiben, dass diese Knochenabtheilung sich sowohl bei Menschen als Thieren findet, ob wir gleich nur einem Theil der Grenzen dieses Knochens an unsern Geschlechter genau bestimmen können, da die übrigen verwachsen und mit der obern äussern Theil der Gesichtsknochen nicht die mindeste Suture oder Harmonie, wodurch man auf die Muthmassung kommen konnte, dass dieser Knochen bei dem Menschen getrennt sei.

In all his views concerning the premaxilla, it is evident that Goethe was saying essentially the things that Vicq D'Azyr had already said six years previously. In later years Goethe published a number of other papers on the premaxilla but these were concerned mainly with the consideration of the relationship of this bone to the varieties of cleft palate, and will therefore not be considered here.

Soemmering, Fischer, Rosenmueller

Soemmering 1794 (23) brings the descriptive anatomy of the premaxilla of the eighteenth Century to a close with a conventional description of the palatine portion of the premaxillary suture, without a reference to either Vicq D'Azyr or to Goethe.

The nineteenth Century is very appropriately introduced to the subject by an exhaustive study of the premaxilla in various mammals by Gotthelf Fischer 1800 (24). To this work it has unfortunately been impossible to obtain access. In the literature examined this work is referred to upon two occasions only, in the study by Goethe already quoted and in a work of Lawrence's soon to be referred to. This work, it would appear, is of some value but rather difficult to obtain.

Rosenmueller 1804 (25) described the endofacial portion of the premaxillary suture in two adult skulls.

Lawrence

Blumenbach's *Manual of Comparative Anatomy* rendered into English by William Lawrence and revised by him was first published in 1807, and revised and augmented by William Coulson in 1827 (26); it contains the following interesting observations on the premaxilla; the original notes, in parentheses, are included:

The upper jaw-bones of other mammalia do not, as in man, touch each other under the nose, and contain all the upper teeth; but they are separated by a peculiar single or double intermaxillary bone, (Gott. Fischer on the different forms of the intermaxillary bones in different animals, with plates, Leipzig, 1800, 8vo; and Kool's *Annotationes Anatomicae*, Gronig. 1800, p. 5) which is in a manner locked between the former, and holds the incisor teeth. (*Vesalius De c. b. fabrica*, p. 46, fig. 1.) It exists also in the pecora, which have no incisor teeth in the upper jaw; as well as in such genera as have no incisor teeth at all, viz. the duck-billed animal, the Cape ant-eater and the proper whales. (On this account I prefer the term intermaxillary

bone to that of *os incisivum*, which is employed by Haller. Blair, in his excellent account of the anatomy of the elephant, calls it, *os palati*, and Viter (*os maxillare interius*) It is joined to the neighbouring bones by sutures, which run externally by the side of the nose and snout, and which pass, towards the palate, close to the foramina incisiva (In human crania, at least those of the foetus and young children, there is at the same part a small transverse slit near the foramen incisivum, of which Fallopius gave the following accurate account in the year 1561 'I find this to be rather a division or fissure than a suture, since it does not separate one bone from the other, nor does it appear exteriorly, nor join two bones, which is the office of sutures' *Obs Anat* How far the alveolar portion of the superior maxillary bones marked by the fissure between them may be regarded as a rudiment of an intermaxillary bone, has been ably shown by Goethe, in the 1st vol of his *Morphologie* Compare Vicq D'Azyr *Mém de l'Acad des Sc* 1780, and *Const Nécrot de Labris leporinis congenitis Natura et Origine Ultras* p 25 In the celebrated dispute of the 16th Century, whether Galen's osteology was derived from the skeleton of man or the ape, Ingrassias argued from the latter side of the question, from Galen's having ascribed an intermaxillary bone to the human subject and the same author, in his classical *Commentarius in Galeni Librum de Ossibus*, Panorm, 1603, fol particularly points out the parts where Galen, led astray by the dissection of apes, deviates from the true construction of the human body) Its form and magnitude vary surprisingly in several orders and genera of mammalia It is small in many ferac, as also in the *walrus* (*trichechus*) In many of the *glirres* (Its great size in these animals is accounted for by the magnitude of the incisor teeth which it contains) it is remarkably large, viz in the *beaver* and *marmot* It is also large in the *hippopotamus*, *porpoise*, and *cachalot*, (*Physeter macrocephalus*) and particularly projecting in the *wombats* Its form is very remarkable in the *ornithorhynchus*, where it consists of two hook-like pieces, joined by a broad synchondrosis † (†I cannot repeat here what I have observed in my book *De Generis Humani Var Nat* on the subject of the intermaxillary bone, of which, as is there stated, not the least trace could be discovered in some *apes* and *baboons*, although the individuals were young It must be inferred, that in these instances, it was consolidated to the neighbouring bones in their foetal state, when all the other sutures were nevertheless in a state of perfection)

The want of the *os intermaxillare* has been regarded as a chief characteristic of the human subject, as one of the leading circumstances that distinguish

man from other mammalia That this bone is really wanting in man must be allowed, notwithstanding the doubts of Vicq D'Azyr The well-known transverse slit, behind the alveoli of the incisors in the human foetus, would form a very slight and remote analogy between the human structure and that of animals, and when we consider that the superior or facial surface of the maxillary bones, so far from being marked by any suture, does not even bear a slit like that of the inferior part, it must be put entirely out of the question

That all other mammalia possess this bone, is not quite so clear as that it is wanting in man The exceptions occur in the quadrumana In addition to those which the author has stated, it may be observed, that the head of an *orang-outang*, in the Hunterian Museum, which possesses all the other sutures, wants those which separate the intermaxillary bone Tyson did not find this bone in his specimen of the animal, which was very young (see his *Anatomy of the Pigmy*), and it did not exist in a cranium which was delineated by Daubenton I have also seen the crania of other monkeys, in which the sutures were all perfect and distinct, although this bone was wanting

It should here be noted that the last two paragraphs above are the additions to Blumenbach's text by Lawrence Blumenbach, it seems, is ready to accept the existence of the premaxilla in man as a fact, as is shown by his reference to Goethe and to Vicq D'Azyr Lawrence, on the other hand, altogether refuses a premaxillary bone to man His cursory reference to Vicq D'Azyr, and the words in which it is couched, indicate that Lawrence's acquaintance with the work he refers to must have been exceedingly slender It seems fairly certain that Lawrence never saw Vicq D'Azyr's paper, for had he seen it he could hardly have dismissed it as easily as he does

Meckel

The younger J F Meckel in his *Pathological Anatomy*, which was published between the years 1812-1818 writes, the quotation being from the English version of 1838 (28),

In several foetuses of three months, we have found it [the premaxilla] composed of three pieces; of these, the anterior comprises the portion of the palatine duct, with the nasal process; the middle, the body and the central part of the palatine process; finally, the third placed externally, the posterior part of this same process. The palatine canal, which is still only a simple hole, the *incisive*, or *anterior palatine foramen* (*foramen incisivum s. palatinum anterius*), appears enormous. The inner, the upper, and the posterior walls of the body are not yet formed. Then, *the anterior portion is separated from the posterior, and a real intermaxillary bone exists*,—a curious analogy with what is normally observed in almost all the animals inferior to man. Even when the two segments are not more entirely distinct, in the full-grown foetus and afterwards, the line of separation extends much farther, both in breadth and in length, across the palatine portion, so that it traverses all the breadth of the upper face. It often happens that it does not stop there, but is reflected upward, and insulates a part from the internal face of the body as an internal thin layer, which is only applied against the external part. Further, a branch of this upper fissure goes inward, and passes behind the lachrymal channel, through the antrum Highmorianum to the posterior face of the body where it unites with the infraorbital canal. We also find some slight traces of this arrangement in the adult; it deserves to be remarked, as indicating, even in man, that the portion of the upper maxillary bone, in which the incisor teeth are situated, is separated from the others during the early periods of life, and then forms a real *intermaxillary bone* (*os incisivum intermaxillare*). We always find in the young foetus the internal branch of the fissure on the under face of the palatine portion, and this observation, together with the instances of division of the upper maxillary bone in the full grown foetus, seems to prove the primitive existence of a special piece of bone for each incisor tooth.

Leuckart

Leuckart's study 1840 (29) has not been available for examination, but according to Ranke (65) Leuckart described and figured the premaxillary bone in a human foetus of about twelve weeks in which the premaxillary suture was quite patent upon the right side of the face only.

Lawrence

Lawrence in his *Comparative Anatomy* 1844 (30) writes:

The want of the intermaxillary bone has been assigned by CAMPER as one of the grand characteristics which distinguish the human head from that of other animals.

The superior maxillary bones of the human subject are united to each other, and contain the whole of the upper series of teeth: they are, however, separated by a third bone of a wedge shape, which contains the incisor teeth, and was therefore called *os incisivum*. Since, however, this bone is found where there are no incisor teeth, as in the horned ruminants, in the elephant, and the two-horned rhinoceros of Africa, and also where there are no teeth at all, as in the anteater and some of the whale kind, BLUMENBACH* (*De Generis humani Varietate nativa, p. 35 [*sic* pp. 33-34] has bestowed upon it the more appropriate name of the *os intermaxillare*. It is a single bone in some cases: in many others, composed of two symmetrical portions. It is connected to the upper jaw-bone by a facial suture, running from the side of the nose to the alveolar margin, and by a palatine suture passing transversely from the alveoli to the anterior palatine foramina.

That man possesses nothing analogous to this intermaxillary bone of the brutes is so clear, that we cannot easily account for that excellent anatomist VICQ D'AZYR† (†Memoires de l'Acad. des Sciences de Paris, 1780) having discovered any analogy in the human jaw to the structure of quadrupeds. The only ground for such an opinion is the small transverse fissure in the palate behind the alveoli of the incisors, observable in the fetus and child, and sometimes tolerably distinct in the adult.† (†The fissure in question is more distinct in young than in old subjects, and it is called by Blumenbach *sutura incisiva* (*Beschreibung der Knochen*.) Although overlooked by several modern osteologists, it was observed and accurately described by the great anatomists of the sixteenth century, Vesalius, Fallopius, and Columbus. It is also mentioned by Riolan (*Anthropographia*, p. 649). Galen has expressly enumerated the intermaxillary bone among the component parts of the human face; and Vesalius very justly inferred from this, among many equally striking proofs, that the anatomical descriptions of that author, which had been universally received with the most implicit deference till that time, had not been drawn from the examination of the human subject. This attempt to rescue mankind from error and prejudice drew upon him nothing but hatred and reproaches from his contemporaries, who were driven to the most absurd arguments in defence of their idol Galen). But there is this very obvious and important distinction; that no vestige of a suture can even be traced in the human subject between the alveoli, much less on the upper and anterior surface

of the jaw: so that the similarity to the structure of the quadruped is very remote.

That all mammalia, besides the human subject, possess this bone is not so decidedly ascertained, as that man has it not, BLUMENBACH§ (§De Gen. Hum. Sect. 1, 15) found no trace of it in the crania of some simiac, although all the sutures were perfect; yet it is seen in the head of the orang-outang (*S. satyrus*) figured by him*, (*Abbildungen n.h. Gegenstände, No. 52) as well as in that of CAMPER.§ (§OEUVRES, pl. 1, fig. 3). On the contrary, in the head of a very anthropomorphous simia in the

premaxilla the very next work to appear upon the subject should give the complete coup-de-grace. This work was a short paper by Leidy 1849 (31) in which a perfect description, supported by two figures, is given of the complete and independent premaxillary bone in man. The relevant part of this work together with the author's excellent figures are here reproduced. Leidy writes,

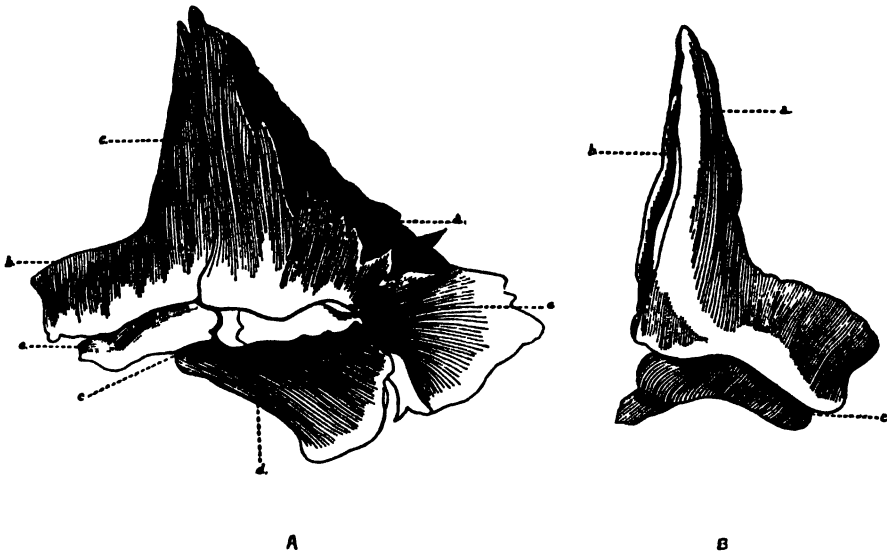


FIG. 2. A REPRESENTS THE SUPERIOR MAXILLARY AND INTERMAXILLARY BONES, MUCH MAGNIFIED, OF A HUMAN EMBRYO

The drawing was taken from the right side through the aid of the camera lucida, which reverses its position. *a.* superior maxillary bone; *b.* intermaxillary bone; *c.* alveolar groove.

FIG. 2. B REPRESENTS THE ANTERO-INFERIOR SURFACE OF THE SEPARATED INTERMAXILLARY BONE, MUCH MAGNIFIED

(From the left side but reversed by the camera.) *a.* ascending or nasal process; *b.* articulating surface for the superior maxillary bone; *c.* incisor alveoli.

museum of the College of Surgeons, which seems to me to be the *S. satyrus*, not a vestige of the sutures separating this bone is to be seen, although the individual must have been very young, as the pieces of the occipital bone are not yet consolidated. According to TYSON and DAUBENTON it is not found in the chimpanzee.

Leidy

It is fitting that to Lawrence's strenuous belief in the non-existence of the human

Recently having had an opportunity of examining several human embryos, in one of them I was fortunate enough to detect the intermaxillary bone as a distinct and independent piece. This embryo measured one inch and eleven lines from heel to vertex, and I presumed it to be about nine or ten weeks old. In its ossification had already advanced in the superior maxillary and intermaxillary bones sufficiently to give them a determinate form, and their appearance when magnified, is represented in the figures 1 and 2, [here figs. 2A and B], which were taken from the specimens through the aid of the camera lucida.

The greatest breadth of the two bones in apposition is one line and two-thirds; the greatest height, being at the ascending or nasal processes and part of the body of the bones; an alveolar ridge and groove and a palatine process projecting backward from the superior maxillary bone. They are easily separable at this period, and the articulation passes through the alveolar ridge, at a point corresponding to the separation between the incisor alveoli, and vertically upwards, dividing the nasal process into two nearly equal portions. On the posterior surface of the nasal process the articulation is at the bottom of a comparatively deep and wide groove, which, however, does not appear to be part of the lachrymal canal, as the latter appears afterwards and external to the former groove. The preparations exhibiting these interesting points which prove the existence of the same law, throughout the animal kingdom, governing the formation of the upper maxillary bones, I present for the inspection of the members of the Academy.

In an embryonic skeleton in the Wistar Museum, measuring three and one-eighth inches in length, and purporting to be about nine weeks old, which, however, I think too young, the maxillo-intermaxillary articulation is still evident at the ascending process, but it does not divide the latter so equally, being more internal and inferior, apparently from a more rapid development of the nasal process of the true maxillary bone. Just above the alveolar ridge they are already ankylosed together.

In another embryo, in the same museum, measuring three and one-fourth inches in length, the two bones have become firmly united, excepting behind the incisor alveoli, but the line of original separation is readily traced out, from a greater degree of thinness and transparency along its course. The nasal process of the true maxillary bone has so much increased beyond the nasal process of the intermaxillary bones, that the latter no longer ascends to the summit of the former, but is considerably inferior and internal.

In the foetal skeleton, measuring five inches in length, all traces of the inter-articulation have disappeared, except behind the incisor alveoli, which latter portion, as is well known, does not usually disappear until some time after birth, and in some instances is found in the adult cranium.

It is a fact worth noting that with the exception of Hamy (46) and Turner (55) Leidy's important contribution has been completely overlooked by all writers concerned with the subject since his day. Had Wood Jones, for example, been acquainted with this work, he could not

have written as he has concerning our supposed ignorance of the form of this bone in man.

Pfeil, Lammers

Pfeil in 1849 (32) and Lammers in 1853 (33) each published a work on the premaxilla in man—which I have been unable to obtain for examination.

Humphry

Humphry 1858 (34) gives a brief but excellent account of the embryological development of the maxilla and neighboring bones in man, and cites much pathological evidence to show that "the intermaxillary bones are developed in connection with the vomer in the median frontal process and they are originally related to it rather than to the maxillary bones." His description of the 'intermaxillary portion' of the 'superior maxilla' is worded as follows,

A delicate linear suture may commonly be seen on the palatine surface of the maxilla, crossing from near the anterior palatine foramen to the interval between the lateral incisor and the canine teeth. This marks out the *intermaxillary bone*, which contains the sockets of the incisor teeth, constitutes the whole thickness of the alveolus, including the floor of the nostril, the anterior nasal spine, and the front wall of the superior palatine hole, and is connected above with the vomer and with the septal cartilage of the nose. The intermaxillary bones form a much more prominent feature in the lower animals. In them they are placed *in front* of the maxillae and are, therefore called "premaxillary bones," they also remain permanently separate from the maxillary bones, and send up a process to unite with the nasal bones on either side, so that, with the nasal bones, they complete the anterior opening of the nostrils.

Bryant, Rousseau

Bryant 1858/9 (35) gives the first description, of what was in later years to become an oft repeated observation, of necrosis of the premaxilla and the removal entire of this bone in a child of three years

following an attack of measles. A few years later 1864 (41) Bryant reported a case of exfoliation of the premaxilla in a laborer aged 40 years following a syphilitic infection acquired at the age of 17. This observation has also been repeated in numerous cases since.

Rousseau 1858/9 (36) attempted to prove, upon purely theoretical grounds, that the premaxillary bone was not normally present in man.

Salter

Salter 1860 (37) reports 20 cases of necrosis and exfoliation of the premaxilla in children following upon apparent recovery from an eruptive fever; two of these cases occurred after an attack of smallpox, four or five after measles, and the remainder after scarlet fever, he writes,

The common characters of all the salient points of these cases and specimens lead me to conclude that the phenomena commence by damage done to certain of the teeth, and forming teeth during the eruptive stage of the fever, and that the bone necrosis and casting off of the teeth, temporary and permanent, and their containing alveoli and loculi is secondary and contingent upon such damage that the *matres morbi* affects the teeth by virtue of their being members of the dermal or tegumentary system—the system upon which the poisons of the eruptive fevers spend their force, and that blighted and irretrievably destroyed, they light up in the surrounding periosteum an inflammation, which, while it is destructive, is curative—while it destroys the bone around—it effects thereby (as by that means alone it could effect) the casting off of the teeth as dead and effete organs.

Such an interpretation is consistent with.

(a). The fact that all these cases occur after, and are always associated with the eruptive fevers

(b) The age of the patient when they happen—from three to six years—a time when the most active nutritional changes are going on in the teeth, and (if the blood be poisoned), a time when the most poisoned blood would be circulating in these organs

(c). The symmetrical character of the disease I have met with but one or two exceptions to this rule in about twenty cases:

(d). The fact that the necrosis is limited to just

so much bone, as will liberate the temporary teeth and the immature permanent, which are shed with it. To this limit I have met with but one exception, and that susceptible of explanation, from the exceptional circumstances attending the case and

(e) That it is unaccompanied by necrosis or exfoliation of any other bone of the skeleton.

Cleland, Jackson, Lewes

Cleland 1861 (38) in making a comparative study of the vomer, ethmoid and premaxillary bones in the mammals, seems, however, never to have arrived at a clear conception of the relationship of these bones to one another in man.

Jackson 1862 (39) reports the case of a boy aged three years and four months, who, following upon an attack of measles, complained of great pain in the mouth. Upon examination the premaxilla was found to be badly diseased. "A loose piece of bone was extracted, which turned out to be the right pre-maxillary bone, and contained the two incisor teeth. He did not attend again."

Lewes 1864 (40) in his *Life of Goethe* gives an excellent account of Goethe's discovery of the premaxillary bone in man, and acknowledges Vicq D'Azyr's right to the priority of the discovery. Lewes himself reports having seen a foetal skull in which the premaxilla was distinctly separated, and, he adds, "I possess a skull, the ossification of which is far advanced at the parietal sutures, yet internally faint traces of the intermaxillary are visible."

Vogt

Carl Vogt 1864 (42) in his admirable *Lectures On Man*, which has been available in the English translation only, makes the following remarks concerning the premaxillary bones,

The incisors are inserted, in all mammals which have them, in a special bone, the intermaxillary, which is generally recognisable throughout life, and remains separated by sutures from those parts

of the maxillary bones which contain the canine teeth and the molars. The elements from which the intermaxillary is developed exist also in man, and are plainly perceptible in the foetus. But it soon becomes confluent with the other bones, so that even in the new-born infant the sutures are generally obliterated, and the union with the upper jaw complete.

At the beginning of this century, when the history of development had as yet made little progress, the absence of the intermaxillary was considered as a specific human character; and Goethe, assisted by that excellent anatomist, Loder of Jena, took great trouble to point out the error. At present it is only the early union which can be cited; but even this has its degrees. We sometimes find in young Negro skulls, as well as in skulls of idiots, traces of the maxillary suture; and, moreover, the sutures in apes are obliterated at various ages. Thus the sutures remain open in the gorilla to an advanced age, and are only closed in the oldest skulls, whilst in the chimpanzee the union takes place immediately after the change of the teeth. I have now before me skulls of the same age, of the genus *Cebus*, in which the teeth had just been shed. In one genus (*Cebus apella*) the intermaxillary is plainly separated; in the other (*Cebus albifrons*) the union with maxillary is so perfect that there is no trace of any suture.

Smith

Smith 1866 (43) considered the relationship of the premaxilla to the varieties of cleft palate; in connection with these he writes " . . . the perfect development of the true maxillaries, indicated by the invariable presence of the canines, is significant of the lesion [cleft palate] being one chiefly affecting or originating in the interposed structures; and in the more characteristic cases the disease is no doubt best marked in its effects on the intermaxillary bones." Double cleft palate, he points out, is generally due to complete absence of the premaxilla.

Eudes-Deslongchamps

Eudes-Deslongchamps 1866 (44) described the premaxillary suture in the skull of a five year old child from Balade. This description is referred to by Osborn in his

Cartwright Lectures (64), and endowed by him with a significance which it apparently does not possess, for although it has not been possible to see Eudes-Deslongchamps' original paper, Hamy, fortunately, quotes it to the following effect: "The suture" writes Eudes-Deslongchamps "between the two bones divides the anterior palatine foramen, having attained towards its middle the canine alveolus. The suture is very clear on both sides. On the anterior inferior aspect of the face the suture is less evident and displays only a very narrow fissure which is hardly perceptible except by the use of a strong light." From this description it seems doubtful whether Eudes-Deslongchamps actually observed more than the palatine portion of the premaxillary suture.

Larcher, Hamy

Larcher 1868 (45) some ten years after the appearance of Rousseau's paper (36) already referred to, is at pains to cite the available evidence in order to refute the latter's statement to the effect that the premaxillary bone is not normally present in man. This he successfully does.

Hamy 1868 (46) in an excellent study of the premaxilla, considers the history, comparative anatomy, embryology, teratology, and pathology of this bone. He states that he has frequently observed the endofacial portion of the premaxillary suture in its entirety in human foetuses, some of which he figures. In a single skull of a New Caledonian infant he observed traces of the premaxillary suture on the right side of the face which were continuous with the palatine premaxillary suture between the canine and lateral incisor teeth. In the skull of a Chellouk infant he observed this suture to run to within a millimeter of the base of the nose. He states, further, that the premaxillary and facial sutures tend to remain open

much later in the prognathous negro races than in the orthognathous white races; this, he believes, is due to the fact that in the negro the facial portion of the skull continues to grow forwards over a period when the bones of the facial skeleton of the white have already attained their final form and relations.

Callender

Callender 1869 (47) was responsible for the first thoroughgoing *developmental* account of the premaxilla in man. Like another notable work with respect to the premaxilla, Callender's study has suffered almost complete oblivion. Its value will be appreciated from the excerpts. One of the main purposes of Callender's study was, in the words of the author, "to supply information regarding some few points with which we are as yet imperfectly acquainted, such as the growth of the maxillae, and the formation and eventual obliteration of the intermaxillary bones." Altogether, Callender examined 20 foetuses ranging between $\frac{1}{2}$ of an inch to 10 inches in length, or between 2 and 7 months of age. Describing a foetus of 2.3 inches, or about 10 weeks of age, Callender states that

At the anterior extremity of the vomer the process of ossification extends to form the intermaxillary bones.

These bones, though their appearances vary in different mammals, have amongst these animals certain common features. (1) The line of articulation with the superior maxilla is in front of the canine socket when the latter is present, when absent the relation of the suture to the maxilla virtually remains unaltered. (2) The premaxilla, as it is more correctly named for these animals, is prolonged superiorly to a point which ascends to a varying distance, or is cut short more abruptly. In any case, whatever be the length of the posterior margin, a groove is found in the anterior edge of the superior maxilla; and into this the wedge-shaped margin, broad or narrow (sometimes almost incisive, as in the sheep), of the praemaxilla is inserted, and is thus

embraced, as it were, by the front border of the upper jaw. (3) The praemaxillae carry the incisor teeth, when present. (4) They articulate in the middle line, sometimes leaving a notch in front for a continuation forward of the septum. (5) They form more or less of the front of the palate, of the boundaries of the incisive foramina, and of the complete or partial septum which separates them.

Passing to an examination of the human foetus, it is evident, from the shape and direction of the incisor process (which is best examined in a foetus 4.3, being then easily detached from the intermaxilla), that it passes across the anterior boundary of the nostril as the latter is continued forward to the middle of the lip. This boundary above is partly covered by the nasal process, below the palatal portion of the superior maxilla ends abruptly behind it, and between the two it is that the incisor process crosses, and indents the orifice of the nostril.

The membrane inflected by the incisor process extends from the middle line (where it is continued forward to be connected with the process of the maxillary lobe which joins it on either side to complete the upper lip), partly below and then behind the incisor process, fills the fissure between that and the palatal, and is continued up behind the nasal process; the groove on the inner surface of this process corresponds with the edge formed by the bending in of the anterior membranous boundary of the nostril, and in the membrane continued back from the angle thus formed there is developed the plate of bone which constitutes the anterior inner or nasal wall of the antrum and the channel for the nasal duct, whilst in the membrane which lies anterior to the groove the intermaxilla of either side originates.

In a foetus 2.3 [10 weeks] the intermaxilla consists of deposits of bone about the posterior edge of the incisor process, which subsequently grow down to form the plate of bone on the inner side of the middle incisor socket, and the posterior wall of the incisor sockets below and internal to the course of the incisor branches of the dental nerve. The front wall of the middle and lateral incisor sockets is continuous, as previously stated, with the plate of bone which covers in the canine notch.

Callender then describes and figures the premaxillary bone as a complete component of the superior maxilla in a foetus, 4.3, between 12 and 16 weeks of age. He concludes:

The preceding observations account for the absence of all trace of the human intermaxillary bone on the facial aspect of the upper jaw in the adult, whilst the

permanent fissure through the palate and on the inner side of the nasal process are equally explained. The bone, in fact, is shut off from the face by the nasal and incisor processes of the superior maxilla. Distinctly outlined at the close of the fourth month; its nasal process, as it may conveniently be termed, is buried in that of the upper jaw, the apex assisting to form a permanent ridge for articulation with the inferior turbinate bone. In a foetus 1.5 I noticed a slight cleft in the nasal process of the superior maxilla corresponding with the top of the groove on its inner surface, but I have never seen anything like an approach to the formation of a distinct anterior plate of bone, such as forms part of the premaxillae of mammals.

Yet despite the peculiarity which results from the formation of the incisor process and the shutting in of the intermaxillaries of man, these bones closely resemble those corresponding with them in mammals. They have a similar wedge-shaped articular surface, fitting a groove in either superior maxilla; they extend towards the middle line and articulate there; they form the anterior extremity of the palate; they bound and divide the incisive foramina; they assist in forming no inconsiderable portion of the sockets for the incisor teeth; that they do not completely form them is a fact occasionally confirmed by the imperfect character of the sockets which lodge these teeth in those cases of cleft palate which have the intermaxillary bones isolated from the superior maxillae.

Another interesting point may be noticed. In some mammals having a slight upper jaw, a sheep for example, the outer wall of the nostril is smooth, there is no vertical ridge, such as that which in man rises to the turbinate bone. In other mammals with strong upper jaws the premaxillae thicken towards their articulation with the superior maxillae, and here is the most prominent vertical line on the nasal surface; beyond this the superior maxillae recede somewhat. There is no such distinct ridge on the upper jaw itself. In man the corresponding ridge is placed about the middle of the ascending process of the upper maxilla, but it results from, and marks none the less, the junction of the nasal process of the intermaxilla with that groove on the inner surface of the upper jaw with which it originally articulated.

Callender's account of the development of the premaxilla in man has never been improved upon. Though numerous observers have concerned themselves with the same problem in the sixty-five years which have elapsed since the publication of his

paper no one has observed so much and so well as he did. For example, the important fact that the premaxilla is replaced anteriorly below the pyriform aperture, entirely by the "incisor process" of the maxilla of each side, has been overlooked by all observers since his time, although Fawcett accepts Callender's description without, however, having confirmed it. It should be clear that as a contribution to the subject with which we are here dealing Callender's paper is of classic rank, since it provides, among other things, the first description and explanation of the changes in the facial skeleton which lead to the obliteration of the premaxillary suture upon the face in man.

Broca

Broca 1869 (48) in his splendid work on the Order of Primates gives a general summary of the existing knowledge concerning the premaxilla in some seven pages. He notices the early obliteration of the suture in the chimpanzee and the late persistence of the suture in the gorilla. Of the orang he writes "il résulte des observations que j'ai faites dans le musée du Collège des chirurgiens de Londres, qu'elle s'effectue après l'éruption des dernières dents de lait, vers l'époque où sort la première molaire." In addition, Broca observes that in man the premaxillaries articulate with the nasal bones.

Sappey, Topinard, Holden

Sappey's *Anatomie* 1876 (49) provides a brief conventional description of the premaxilla in man, from which it is, however, impossible to gain an accurate idea of the complete form and relationships of this bone.

Topinard both in his short 1878 (50) and large 1885 (57) volumes on anthropology, has but a brief reference to the premaxilla.

Holden 1878 (51) in his *Osteology* gives

the usual ordinarily conventional description of the premaxilla.

Albrecht

Albrecht 1882 (52) in a study of the varieties of cleft palate and hare-lip is concerned to show that each half of the premaxilla develops from two distinct centres, each incisor tooth being supported by an individual premaxillary element, and upon this theory attempts to explain the various forms of cleft palate and hare-lip.

Kölliker

Kölliker 1882 (53) treated the heads of young embryos between 8 and 9 weeks of age with a 10 per cent solution of caustic potash. In from anything between an hour and 24 hours this solution rendered the soft parts of the head transparent, so that the white centres of ossification beneath were easily seen. According to Kölliker, the premaxilla is formed in the naso-frontal process at about the seventh week and unites with the maxilla at about the ninth. Each premaxilla contains two incisors; the enamel-germ, however, is formed as one continuous plate in the upper and lower jaws respectively, there is therefore no exact correspondence between the original formation of the bones and that of the teeth. It may thus be understood how in the case of double hare-lip the middle premaxilla contains sometimes two, and at other times three or four incisors, or even more.

Allen

Allen 1882 (54) gives a brief clear account of the premaxilla in the conventional manner. He believes that there are two centres of ossification for the premaxilla "one on either side of the median line in the position of the premaxillae of lower animals," and that these centres appear as early as the sixth or seventh

week of development. Allen gives the following interesting description of a case of early loss of the premaxilla:

A gentleman, aged sixty, was much annoyed by a defect which prevented his dentist fitting a plate for artificial teeth. The patient was edentulous, and had had from early childhood a cleft in the incisorial position of the upper jaw, which, as he had been informed by his parents, was caused by the loss of bone following an attack of measles. The cleft was a little to the right of the median line, and extended upward to the floor of the nose and backward along the roof of the mouth about an inch. The sides of the cleft were for some distance in contact, but posteriorly a delicate probe could be introduced into the nose. The entire right side of the dental arch was more incurved than the left. Acquired malformation of the hard palate, the result of early loss of the left premaxilla, was diagnosed.

Bland Sutton

Bland Sutton 1884 (56) describes the premaxilla in man as follows:

It comprises that portion of the superior maxilla which lodges the two incisor teeth; from its mesial surface a horizontal portion projects backwards to form the inner boundary of the anterior palatine canal. Superiorly it has a vertical portion, which forms the lower and outer boundary of the anterior nares, and in well-marked cases it sends up a spiculum to articulate with the nasal bone.

Dr. Paul Albrecht recently communicated to the Société d'Anthropologie de Bruxelles a paper to the effect that the premaxillary bone is, as a matter of fact developed from two centres, and supports his view by references to cases of cleft-palate and hare-lip. I have examined some cases of cleft-palate and can support Albrecht's statements, but in the normal condition there is only one centre for each premaxillary bone. The discrepancy may be thus explained: the premaxilla is originally developed in membrane, and at some little distance from the median line, which, in the foetus, is occupied by the thick cartilage known as the ethmo-vomerine plate. After a time the premaxillary ossifications involve the anterior extremity of the cartilage, so that the inner portions of these bones are really of cartilage origin. If anything interfere to prevent the premaxillary bone or bones meeting the ethmo-vomerine plate, the tip of this cartilage ossifies on its own account, and gives rise to the false notion of two centres occurring normally.

Bland Sutton has some good figures of the human premaxilla.

Turner, Broca, Berard

Turner 1884 (55) discusses the relationship of the form and structure of the premaxilla to cleft palate. Among seven infant skulls Turner found two in which the premaxillary suture was visible on the palate, on the floor of the nose, and on the nasal aspect of the ascending process of the superior maxilla.

Broca 1887 (58) similarly discusses the relationship between the premaxilla and cleft palate.

Berard 1888 (59) investigated the premaxilla in the Primates, but unfortunately I have been unable to obtain an idea of his results owing to my inability to obtain a copy of his work.

Kölliker, Biondi

Kölliker 1888 (60) sustains the view that the premaxilla is ossified from two distinct centres, one on each side of the median line.

Biondi 1888 (61) in an accompanying discussion disagrees with Kölliker concerning the number of ossification centres for the premaxilla, and attempts to show that each premaxilla is generated by two distinct centres for each side, altogether four distinct centres, in opposition to Kölliker's total of two.

Gilis, Allen

Gilis 1888 (62) describes a skull upon the palate of which an additional element of the premaxilla was situated—between the endognathic divisions of the premaxilla. This case, Gilis believes, tends to support the theory of a distinct separate element for the lodgement of each incisor tooth.

Allen 1890 (63) gives an interesting description, from his medical practice, of a

number of cases of hyperostosis of the premaxillary portion of the nasal septum, which he describes as lying "anteriorly, between the triangular cartilage and the floor of the nose," that is to say, the vomerine portion of the premaxilla.

Osborn

Osborn 1892 (64), who is the "Cartwright Lecturer" referred to by Wood Jones upon an earlier page, writes "The human premaxillary, a discovery with which Goethe's name will always be associated, is sometimes partially, more rarely wholly, isolated; it is late to unite with the maxillary in the Australians, and has been reported entirely separate in a New Caledonian child (Deslongchamps) and in two Greenlanders (Carus)."

With respect to Deslongchamps' study 1866 (44) it is obvious from Hamy's (46) reference to it that Deslongchamps was referring chiefly to the palatine premaxillary suture, and not to the facial premaxillary suture. Carus' study it has been impossible to trace.

Sussdorf, Testut

Sussdorf 1895 (66) has a short but comprehensive discussion of the comparative anatomy of the premaxilla.

Testut's *Anatomie* 1899 (67) gives a short but comprehensive review of what was known of the premaxilla at that date, without reference, however, to the more obscure features of the bone.

Frison

The twentieth Century opens with a study of the premaxilla by Frison 1901 (68). In this work Frison treats of the human premaxilla from the pathological point of view, and he cites some twenty-six cases in which the premaxilla was the only bone in the skull to be affected by disease. Inflammation, and often exfolia-

tion, of the bone may, according to Frison, follow upon any of the eruptive fevers—particularly scarlatina, and may occur during any of the tertiary stages of syphilis. Frison accounts for this peculiar sequestration of the premaxilla in such diseases in the following way: The maxilla is composed of compact tissue, whereas the premaxilla is composed almost entirely of spongy bone. Spongy bone, it is well known, is less resistant to infection than compact bone. The premaxilla has an independent blood supply (the spheno-palatine) artery; when, then, infection occurs in the premaxilla the blood supply is very easily arrested, with the result that necrosis of the bone soon takes place.

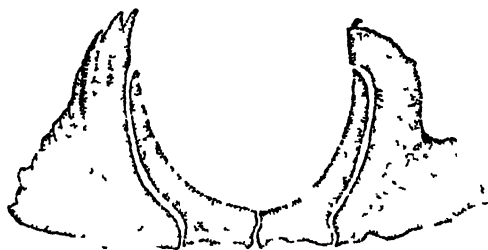


FIG. 3 SHOWING THE TWO HALVES OF THE PREMAXILLA COMPLETELY SEPARATED FROM THE MAXILLA IN A HUMAN FOETUS AT THE BEGINNING OF THE THIRD MONTH
After Ranke

Ranke

Ranke 1901 (69) in an interesting paper deals fairly exhaustively with the palatine portion of the premaxillary suture in the Primates. Among other things, he describes and figures the completely patent facial portion of the premaxillary suture in a human foetus of 28 mm., that is, at the beginning of the third month (Fig. 3).

Jeffery

Jeffery 1904 (71) reports the case of a young woman aged twenty years in whom the premaxilla was completely absent. In early life this young woman had been

operated on for hare-lip, but at 20 there was still no bony union between the maxillae. In the canine portion of the maxilla Jeffery found what he describes as "a tiny tooth which might have been a relic of the lateral incisor"; he does not state, however, from which side of the maxilla this "relic" was removed.

Fischel

Fischel 1905 (72) described the skull of a middle-aged woman in which the premaxilla was either completely absent or only rudimentarily developed. The maxillary incisors were absent, and there was no anterior nasal spine. As a result of the absence of the premaxilla the palate assumed an unusual pyramidal form, being 37.0 mm. in length, 38.0 mm. broad posteriorly, and only 15.0 mm. broad between the alveoli of the first premolars. An anterior palatine foramen of more than usual dimensions was present which was bordered by the free margins of the maxillae. Fischel ascribed the absence of the premaxilla in this case to an early failure of development, but the evidence from the figures of the skull he describes suggest rather a post-natal pathological loss of the premaxilla.

Mosher

Mosher 1909 (76) considered the relation of the premaxilla to disorders in eruption of the maxillary incisors, prognathism, and deflection of the nasal septum. He considers merely the palatine and vomerine portions of the premaxilla. He finds that the premaxilla is less reduced in the negro than in the white, a fact which to some extent explains the alveolar incisorial prognathism of the negro. Mosher shows further, that deflection of the nasal septum may often be caused by the irregular or excessive growth of the vomerine portion of the premaxilla.

Le Double

Le Double 1906 (73) has a fairly full discussion of the premaxilla, but no conception of the form of the bone as a whole can be gained from it. Le Double notes that in the newborn and young chimpanzees the premaxillary facial suture is generally obliterated in its lower two-thirds; and that in the adult and old animals the suture is completely obliterated. It is interesting to note, he adds, that the disappearance of this suture occurs from below upwards as is the case in man.

The works of Rabl 1920 (70), Anderson 1908 (74), Preiswerk 1908 (75), Hopf 1909 (77), Bruni 1911/12 (79), and Frets 1912 (80), are of general interest in connection more particularly with the development and form of the palatine portion of the premaxilla in man and the remainder of the Primates; so too, are the works of Murakami 1928 (97), and Mijsberg 1928 (98).

Fawcett

Fawcett 1911 (78) in what is undoubtedly the most comprehensive original study of the maxilla and associated structures, states that he has never observed the facial portion of the premaxilla upon the face in embryos. In this study Fawcett gives, for the first time, a thorough explanation of the nature of the fissures which appear upon the oral surface of the premaxilla. "These" writes Fawcett "are due to the fact that the backs of the two incisor teeth are early covered, each of them, by down-growths of bone from the premaxillary mass; and these coverings, not only growing downwards, but at the same time backwards, produce elevations which imperfectly meeting, result in intervening fissures."

Inouye

Inouye 1912 (81) has published the most exhaustive study of the premaxilla in man in existence. This study is a very long

one. Possibly the most important fact in this work, from our point of view, is the author's description of the persistence of the superior portion of the premaxillary suture upon the face in a one year old child. A drawing of the skull is given by Inouye. Of the condition he writes,

Wie Fig. 3 deutlich zeigt, beginnt die Naht an der Mitte des Seitenrandes des Nasenbeines, läuft dann auf dem Processus frontalis des Oberkiefers parallel seinem medialen freien Rande, um nach einem ziemlich langen Verlaufe in einem kleinen Gefässloche zu verschwinden; die Länge der Suture beträgt 1.3 cm. Der Verlauf dieser Naht entspricht genau dem der zur Furche geschlossenen Suture, die bereits auf der nasalen Fläche des Stirnfortsatzes des Oberkiefers beim Kinde besehen worden ist.

Thus, it is to be observed "dass die nasale Sutura incisiva nicht am Rande der Apertura piriformis, sondern am Seitenrande des Nasenbeines endet. . ."

Inouye points out that in the Old World Monkeys which he had an opportunity of examining the relationship of the ascending process of premaxilla to the nasal bone is similar to the human condition. A similar relationship was observed in a young orang, though in the gorilla the ascending process terminated at the superior pyriform aperture.

Bolk

Bolk 1913 (82) in his lengthy work on the obliteration of the sutures in the primate skull, gives a detailed report of his findings with respect to the premaxillary suture. His conclusions, briefly summarised, are as follows: Obliteration begins in the

Foetal period in Man, Chimpanzee.

Infantile period in *Cebus*, *Chrysotrichus*, Orang.

Juvenile period in Siamang.

Mature period in *Macacus* ♂, Gorilla, *Cercopithecus*

Adult period in *Alouatta*, *Ateles*, *Haplorhina*, *Semnopithecus* ♂ and ♀, *Cynocephalus*, *Colobus*

Bolk thinks that there is probably some relationship between the degree of prog-

nathism displayed by any Primate and the period at which obliteration of the premaxillary suture takes place.

Walker

Walker 1917 (83) reports a case of absence of the premaxilla in an English boy aged 14 years. Walker's own summary of the case is as follows:

1. The case shows complete absence of the premaxilla, with the four upper incisors and deficient ossification of the nasal septum. Other malformations are absent.

2. The two maxillary processes have grown forwards and inwards, have met each other and the nasal septum in the mesial plane, carrying the canines into the incisor portion, and have filled the space left by the pre-maxilla.

3. The history of the case is open to doubt, but it suggests that the premaxilla was sloughed at the age of three during an attack of measles. A previous deficiency of attachment must be supposed. Congenital defect of the mesial nasal process is evidenced by the condition of the existing nasal septum.

Richardson

Richardson 1918 (84) reports the case of a young man, aged 26, who complained of intense pain in the floor and lateral wall of the left nasal chamber. In order to relieve the pain the four maxillary incisors were removed, but in a short time the premaxilla became entirely necrosed and separated from the maxilla in a single mass. Richardson cites as an important and salient feature of this case the fact of the complete limitation within distinct anatomic borders of the bony necrosis, affecting only the premaxilla. In the discussion of this paper Dr. H. L. Swain refers to a precisely similar case which came under his notice.

Felber, Jarmer, Herbst

Felber 1919 (86), and Jarmer 1922 (87) have independently investigated the embryological development of the premaxilla in man; their conclusions are in substantial agreement. They are in agreement that

the centers for the premaxillary bones first make their appearance at the beginning of the seventh week of development, slightly after the appearance of the ossification centers for the maxilla, and that by the conclusion of the twelfth week the facial portions of the premaxillary bones become completely united with the maxilla.

Herbst 1923 (88) has a very thoroughgoing discussion of the premaxilla in relation to the varieties of hare-lip and cleft palate.

Bercher and Merville

Bercher and Merville 1923 (89) and (90) report four cases of necrosis of the premaxilla occurring during the tertiary stages of syphilis in four adult soldiers. In each case all the marked characters of congenital syphilis were present.

Bercher 1924 (91) comments upon the predisposition of the premaxillaries to disease in such disorders as syphilis and the eruptive fevers.

Vallois and Cadenat

Vallois and Cadenat 1924 (92) examined the premaxillary region in 30 human foetuses between the second and seventh months of development; they write:

Le prémaxillaire est visible pour la première fois sur un embryon de 21 mm., c'est un petit noyau situé en avant de la lame dentaire, dans la région qui correspond aux futures incisives. Très rapidement, il se soude à celui du maxillaire qui est apparu plus tôt et occupe la future région molaire. L'union des deux centres forme une lame osseuse qui borde en dehors la lame dentaire.

À 41 mm., cette lame envoie en haut 2 prolongements, l'un correspondant à sa portion maxillaire, l'autre à sa portion prémaxillaire; ce sont les processus frontaux. Le processus frontal du prémaxillaire borde, par son bord antérieur, l'orifice nasal. Son bord postérieur est longé par le processus frontal du maxillaire, dont un interstice le sépare. À 44 mm le prémaxillaire; et son processus frontal, bien développés, constituent une lame compacte qui s'étend de la gouttière vestibulaire à l'os nasal. La face interne (bucco-nasale) de cette lame se prolonge en dedans par un tissu osseux à mailles l'âches, qui forme le fond

et la paroi linguale des alvéoles des incisives et s'enfonce dans la partie correspondante du palais dont il constitue le squelette. C'est le prolongement palatine du prémaxillaire. Sa partie la plus interne émet une petite languette qui se dirige d'avant en arrière, le long de la ligne médiane. Par homologie avec la disposition des animaux, on peut l'appeler processus palatin médian. Tout le reste du prolongement sera lors dit processus palatin latéral. Dans l'échancrure qui sépare les 2 processus passe le canal de Stenson.

En arrière, une suture très nette, la suture incisive, sépare le prolongement analogue émis par la maxillaire. Au cours du 4^e mois, se produisent certains changements. Le processus frontal du maxillaire, d'abord situé en arrière de celui du prémaxillaire, pousse en dehors de lui une lame qui recouvre en partie sa face externe. En même temps, les 2 processus se soudent l'un à l'autre, mais le trace de la séparation primitive reste encore visible sur leurs faces externe et interne. Le processus palatin latéral s'accroît notablement; c'est maintenant une épaisse lame qui forme toute la partie de la voûte palatine correspondant aux incisives; son bord postérieur, bilobé, limite la suture incisive. . . .

Au cours des 5^e & 6^e mois, le prémaxillaire perd la plus grande partie de son indépendance. Son apophyse frontale est presque totalement recouverte en dehors par l'apophyse frontale du maxillaire et lui est complètement soudée. Sur la face externe, la ligne de suture est visible pendant quelques temps comme un fin sillon qui longe dehors le pourtour de l'orifice nasal. Sur la face interne, la ligne de suture est plus postérieure; elle disparaît de bas en haut, la soudure débutant au niveau du cornet inférieur.

Thus, it seems clear from both Callender's and Vallois' and Cadenat's observations that the premaxillary suture disappears upon the facial aspect of the human skull early in development because the premaxilla becomes completely, or almost completely, covered by the facial process of the maxilla, with which it apparently becomes indissolubly united, although, as Vicq D'Azyr long ago showed, the suture upon the internum of the maxilla may persist late into the post-natal development of the individual. Superficially understood this manner of development may be construed to be appreciably different from that which takes place in the sub-human Pri-

mates, and, indeed, there certainly exists a difference in the *degree* of development, but not in the *kind*. For, as we shall see, the present form and structure of the premaxilla in man represent the expression of an active process of the involution which this bone has for a considerable period of time been undergoing as a result of the important series of changes which have taken place in the oral-olfactory life of man.

Remane

Remane 1927 (96) investigated the period of closure of the premaxillary suture in the anthropoid apes. For the chimpanzee he finds that "Bei allen Individuen, auch den jüngsten, ist der untere Teil der fazialen Naht verschlossen," and this always before birth. The suture is in most cases already obliterated at the conclusion of the juvenile period. In the gorilla the suture is found persistent in most adults. In the orang two structurally dimorphic groups are recognisable with respect to the period of obliteration, although no sexual difference is discoverable. In the first "beginnt der Verschluss bald nach Vollendung des Milchgebisses." In the second "wächst die Intermaxillarnahat kurz vor Vollendung des Dauergebisses." In the gibbon "treffen wir denselben Dimorphismus wie beim Orang in noch verstärkter Form an." Remane's conclusions are as follows with respect to the period of obliteration:

Beim Schimpansen, als einzigem Primaten ausser dem Menschen, beginnt der Verschluss regelmässig vor der Geburt. Der Abschluss der Obliteration liegt jedoch nicht selten nach Vollendung des Dauergebisses. (Innere palatinaler Teil).

Der Gorilla verschliesst bis auf seltene Ausnahmefälle die Naht erst zur Zeit oder kurz nach Vollendung des Dauergebisses. Der Orang und die Hylobatiden zeigen einen Dimorphismus, ein Teil der Tiere beginnt mit dem Verschluss zur Zeit der Vollendung

des Milchgebisses oder kurz nachher, ein anderer erst kurz vor Vollendung des Dauergebisses

With respect to the manner of obliteration Remane writes, "Beim Schimpanse und Gibbon der Verschluss direkt am Alveolarrand dehnt sich von hier z.T. etappenweise sowohl auf die faciale wie auf die palatinale Naht aus; beim Gorilla und noch mehr beim Orang beginnt er fazial ein Stück oberhalb des Alveolarrandes, palatinal in der Regel im Zwischenteil."

Ehrhardt

Ehrhardt 1930 (103) examined the large collection of anthropoid crania at Munich in order to check Remane's conclusions. She finds that "der Mensch und der Schimpanse haben von den Anthropomorphen das relativ am schwächsten entwickelte Gebiss, beide zeigen den frühen Nahtverschluss." Her conclusions are,

I Die ersten Verwachsungstretten beim Orang-Utan und Gibbon mit Vollendung des Milchgebisses und kurz nachher, vermutlich auch kurz vorher, auf Die Zahl der Schadel, die noch in Beginn der Verwachsung stehen, nimmt mit steigender Altersstufe allmählich ab Die ersten Schadel mit vollkommen verschlossener Naht treten beim Orang-Utan in V, beim Gibbon in der IV. Altersstufe auf (IV Beginnender bis nahezu vollendeter Durchbruch von Eckzahn und letztem Molar V. Gebiss vollendet). Beim Orang-Utan und Gibbon verwächst die Sutura incisiva kontinuierlich, im Verwachsen zeigt sich kein Dimorphismus

II Beim Gibbon verwächst die Sutura incisiva früher als beim Orang-Utan.

With respect to the manner of obliteration:

I. Beim Orang-Utan beginnt die Verwachsung faciale, etwas oberhalb der Alveole Der faciale Teil verwächst, abgesehen von nasalen Nahtresten, früher als der palatinale.

II. Beim Gibbon (*Hylobates concolor*) beginnt zuerst der palatinale Teil alveolar zu verwachsen. Der faciale Teil schließt sich jedoch auch hier früher.

III. Beim Siamang (*Symphalangus syndactylus*) erfolgt der Verschluss als *Hylobates concolor*, nur der faciale Teil verwächst an der Alveole später.

Ehrhardt notes that obliteration of the premaxillary suture in the Orang and Gibbon takes place earlier in the female than in the male.

Herbst and Apffelstaedt

Herbst and Apffelstaedt 1930 (104) have an excellently clear discussion of the relation of the premaxilla to the varieties and forms of cleft palate and hare-lip.

Krogman

Krogman 1930 (105) in a study of suture-closure in the Primates, states that the premaxillary generally closed about the time of eruption of the first permanent molar in the gibbon, about the time of eruption of the deciduous teeth in the orang, rather earlier in the chimpanzee, and in the pre- or early adult period in the gorilla. In *Papio hamadryas* the suture undergoes obliteration not before the adult period. With respect to *Psthecus rhesus*, he agrees with Bolk (82) "that closure of these sutures starts in the male in the pre-adult period (eruption of second molar), and that in the female they are always patent"

Augier

Augier 1932 (110) has recently published an extremely interesting study of the premaxilla based upon his observations of the conditions in early human embryos. He states that the two maxillary centers appear at the 15 mm. stage, whilst the premaxillary centers appear at the 26 mm. stage, and generally unite with the maxilla at the 30 mm. stage. Augier writes "La soudure précoce des centres maxillaires humains est en rapport avec leur régression." This regression may be re-

garded as a result of the unique orthognathism of the human face.

Nous sommes hypothétiquement persuadés que ce temps d'apparition est le même chez tous les Primates, parce que chez l'Homme, où la réduction est la plus marquée, le prémaxillaire reste aussi précoce qu'il puisse être (c'est le troisième centre céphalique).

Chez trois animaux (Homme, Cochon, Cobaye) où l'architecture bucco-nasale diffère beaucoup, mais où l'importance dentaire du prémaxillaire reste grande, nous voyons ce centre apparaître d'une façon à peu près comparable (Mandibule, Postmaxilla, Prémaxilla, Frontal chez le premier; Mandibule, Postmaxilla, Frontal, Prémaxilla chez les deux autres). Chez le Mouton (malgré un matériel abondant, nos résultats restant provisoires), où l'architecture faciale diffère *relativement* peu de celle des deux autres Quadrupèdes, mais où l'importance dentaire (Nous ne disons pas buccale) de cet os est nulle, son centre apparaît un peu plus tardivement; le prémaxillaire semble y être le quatrième ou le cinquième ou le sixième centre céphalique."

Augier concludes "que c'est le développement plus ou moins précoce des dents qui décide du développement plus ou moins précoce du prémaxillaire."

Limson

Limson (1932) (111) examined the macerated skulls of 142 white and negro foetuses, in addition to 32 infants ranging in age from birth to 2 years of age, the purpose being to record "the many significant variations in the bones of the skull during the fetal and early infantile periods of development." Of the premaxilla Limson writes,

In all the fetal and infantile skulls the intermaxillary is completely fused with the maxillary bone on the outer surface, but is entirely separated from it on the oral surface by means of the suture incisiva. This suture was invariably found to extend from the foramen incisivum to the interalveolar septum between the lateral incisor and canine. The same suture is also visible on the floor of the nasal cavity and proceeds, at least in prenatal growth stages, for some distance along the inner surface of the ascending process. It is very interesting that this suture between maxillary

and intermaxillary is not only regularly present on the lateral wall of the fetal nasal cavity, but lies closer to the margo lacrimalis than to the lateral edge of the apertura piriformis, indicating an unexpectedly broad nasal process of the intermaxillary bone. As stated above, no trace of this ascending suture could be detected on the outer surface of even the youngest fetal skulls examined.

Franz

Franz (1933) (115), a short time after this paper was completed, published an extremely important paper bearing upon the whole question of Goethe's premaxillary contributions. It seems quite clear from Franz' discoveries that Goethe was aware of Vicq D'Azyr's publication of six years antecedent to his own, but for some mysterious reason preferred to keep silent concerning it. For a full discussion of the matter the reader should refer to Franz' splendid paper.

Summary of the literature

This concludes our survey of the literature dealing with the premaxilla; it may be summarised in the following words:

The human premaxilla is a bone of very definite form and structure, it is a perfect homologue of the equivalent structure possessed by the lower mammals. The bone undergoes ossification from at least two distinct centers, which appear first during the seventh week of development, when after, according to its observers, at or about the end of the twelfth week of development the facial portion of the premaxilla apparently becomes completely or almost completely overgrown, or overlaid, by a plate of ossificatory material, originating in the matrix of the maxilla, with which it subsequently becomes more or less inseparably united. It is clear too, that in some cases the premaxilla may persist in its entirety, ununiting to the maxilla, as a distinct and independent

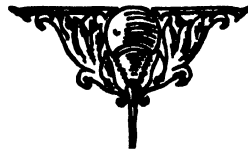
entity, or that it may be entirely absent, produced, or retracted owing to disease or failure of development, and finally, that it may become sharply sequestered from the adjacent bones following upon local inflammation or disease.

The premaxilla, it is observed, is composed of two bilaterally symmetrical units, each consisting of three arbitrary but easily recognisable parts, namely, a *body*, a *palatine process*, and an *ascending* or *naso-maxillary process*.

Inferiorly each body contributes towards the support of the two incisor teeth (to what extent I shall show later). From

the body arise two processes, the palatine and the ascending or naso-maxillary processes. The palatine process plays a part in the formation of the anterior moiety of the palate and the floor of the nasal cavity, and also helps to form the incisive foramen, finally, upon its narial surface giving rise to a keel-like process which helps to complete the vomer anteriorly. The naso-maxillary process contributes towards the formation of the whole extent of the internal anterolateral boundaries of the pyriform aperture.

(*To be concluded*)



EXPERIMENTAL STUDIES ON THE DURATION OF LIFE.

XIV. THE COMPARATIVE MORTALITY OF CERTAIN LOWER ORGANISMS

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I

THE first complete life tables based upon comprehensive and accurate observations for any other organism than man, were, so far as we know, those published in the first of this series of Studies by Pearl and Parker (30) in 1921 for normal wild-type *Drosophila melanogaster*, and for its mutant *vestigial*. Since that time partial or complete life tables for *Drosophila* have been published by Pearl and Parker (31) for line-bred strains; (32) showing effect of successive etherizations; (33) demonstrating influence of density of population on duration of life; (34) influence of ventilation and of feeding embryonic juice; (35) re-computed life tables; (36) for duration of life in the complete absence of food. Pearl, Parker and Gonzalez (37) have published life tables on the Mendelian inheritance of duration of life in *Drosophila*, and on the effect of surgically removing the wings upon duration of life. Gonzalez (12) computed *Drosophila* life tables showing the relation of certain mutant genes to duration of life; Pearl, Miner and Parker (29) on the effect of density of population; Alpatov and Pearl (2) on the effect of temperature; Alpatov (1) on the effects of feeding; and Steinfeld (43) on the effects of a sterile environment. For other non-human forms the following life tables have been published: for the saturniid moth *Teia polyphemus* a graph of the ungraduated survivorship line by Pearl and Parker (35) based on data published by Philip and N. Rau (40); for

the rotifer *Proales decipiens* by Pearl and Doering (26) based on data published by Noyes (19); and for mice by Greenwood (14) based on data from Leonard Hill and J. A. Murray. Data on life duration without the computation of life tables have also been given by Hase (16) for the common *Hydra fusca*; by Rau (39) for the roach *Blatta orientalis*; and by the Szabós (45) for the slug *Agriolimax agrestis*. Recently Gardner and Hurst have published life tables for the domestic fowl (10). Certain of these data, not previously graduated, have been fitted with the following equations:

Hydra fusca:

$$\log_{10} 1000 q_x = 1.053 + 0.052 x - 0.0059 x^2 + 0.00023 x^3$$

(Origin at 2 days; x unit = 5 days)

Agriolimax agrestis:

$$\log l_x = e^{-0.0416x} (3 - 0.0248 x + 0.0283 x^2 - 0.0031 x^3)$$

Blatta orientalis:

$$\log_{10} l_x = 1.188x (3 - 0.525 x + 0.059 x^2 - 0.016 x^3)$$

(Origin at 0 days; x unit = 15 days)

Starved wild (Line 107) *Drosophila*:

$$l_x = \frac{1100}{1 + 0.100e^{0.0077x} + 0.00000077e^{0.78x}}$$

(Origin at 0 hours; x unit = 1 hour)

Starved vestigial *Drosophila*:

$$l_x = \frac{1000}{1 + 0.0000100e^{-0.1000x} + 0.00000000182e^{+0.6180x}}$$

TABLE I
Complete life table for *Hydra fusca*

AGE	l_x	d_x	$1000q_x$	o_x	AGE	l_x	d_x	$1000q_x$	o_x	AGE	l_x	d_x	$1000q_x$	o_x
days					days					days				
0	1000	11	10 8	54 9	50	476	7	16 2	39 4	100	175	5	32 0	16 7
1	989	11	11 0	54 5	51	469	8	16 2	39 1	101	170	6	33 3	16 2
2	978	11	11 3	54 1	52	461	8	16 2	38 7	102	164	6	34 6	15 7
3	967	11	11 6	53 7	53	453	7	16 2	38 3	103	158	5	36 1	15 3
4	956	11	11 8	53 3	54	446	7	16 2	37 9	104	153	6	37 6	14 8
5	945	12	12 1	53 0	55	439	7	16 3	37 6	105	147	6	39 3	14 4
6	933	11	12 3	52 6	56	432	7	16 3	37 2	106	141	6	41 1	14 0
7	922	12	12 6	52 2	57	425	7	16 3	36 8	107	135	5	43 1	13 5
8	910	11	12 8	51 9	58	418	7	16 4	36 4	108	130	6	45 0	13 1
9	899	12	13 1	51 6	59	411	7	16 4	36 0	109	124	6	47 1	12 7
10	887	12	13 3	51 3	60	404	6	16 4	35 6	110	118	6	49 3	12 3
11	875	12	13 5	50 9	61	398	7	16 5	35 1	111	112	5	51 5	11 9
12	863	12	13 7	50 6	62	391	6	16 5	34 7	112	107	6	53 9	11 5
13	851	12	13 9	50 3	63	385	7	16 6	34 3	113	101	6	56 4	11 2
14	839	11	14 1	50 0	64	378	6	16 7	33 9	114	95	5	59 0	10 8
15	828	12	14 2	49 7	65	372	6	16 8	33 4	115	90	6	61 7	10 4
16	816	12	14 4	49 4	66	366	6	16 8	33 0	116	84	5	64 5	10 1
17	804	11	14 6	49 1	67	360	7	16 9	32 6	117	79	6	67 5	9 8
18	793	12	14 7	48 9	68	353	6	17 0	32 1	118	73	5	70 6	9 4
19	781	12	14 8	48 6	69	347	6	17 2	31 7	119	68	5	73 8	9 1
20	769	11	15 0	48 3	70	341	5	17 3	31 2	120	63	5	77 2	8 8
21	758	12	15 1	48 0	71	336	6	17 4	30 7	121	58	5	80 8	8 5
22	746	11	15 2	47 8	72	330	6	17 6	30 3	122	53	4	84 5	8 2
23	735	11	15 3	47 5	73	324	6	17 7	29 8	123	49	4	88 4	7 9
24	724	11	15 4	47 2	74	318	5	17 9	29 3	124	45	4	92 4	7 6
25	713	11	15 5	46 9	75	313	6	18 1	28 9	125	41	4	96 7	7 3
26	702	11	15 6	46 7	76	307	6	18 3	28 4	126	37	4	101 1	7 1
27	691	11	15 7	46 4	77	301	5	18 5	27 9	127	33	4	105 8	6 8
28	680	11	15 7	46 1	78	296	6	18 8	27 4	128	29	3	110 6	6 6
29	669	10	15 8	45 9	79	290	5	19 0	26 9	129	26	3	115 7	6 3
30	659	11	15 9	45 6	80	285	6	19 3	26 5	130	23	3	121 0	6 1
31	648	10	15 9	45 3	81	279	5	19 6	26 0	131	20	2	126 6	5 8
32	638	10	15 9	45 0	82	274	6	20 0	25 5	132	18	3	132 4	5 6
33	628	10	16 0	44 8	83	268	5	20 3	25 0	133	15	2	138 5	5 4
34	618	10	16 0	44 5	84	263	6	20 7	24 5	134	13	2	144 8	5 2
35	608	10	16 0	44 2	85	257	5	21 1	24 0	135	11	1	151 5	5 0
36	598	9	16 1	43 9	86	252	5	21 5	23 5	136	10	2	158 5	4 8
37	589	10	16 1	43 6	87	247	6	22 0	23 0	137	8	1	165 7	4 6
38	579	9	16 1	43 3	88	241	5	22 4	22 5	138	7	1	173 4	4 4
39	570	9	16 1	43 0	89	236	6	23 0	22 1	139	6	1	181 3	4 2
40	561	9	16 1	42 7	90	230	5	23 5	21 5	140	5	1	189 7	4 0
41	552	9	16 1	42 4	91	225	6	24 1	21 0	141	4	1	198 4	3 8
42	543	9	16 2	42 1	92	219	5	24 8	20 5	142	3	1	207 5	3 7
43	534	9	16 2	41 8	93	214	5	25 5	20 0	143	2	0	217 0	3 5
44	525	8	16 2	41 5	94	209	6	26 2	19 5	144	2	1	227 0	3 3
45	517	9	16 2	41 1	95	203	5	27 0	19 1	145	1	0	237 4	3 2
46	508	8	16 2	40 8	96	198	6	27 9	18 6	146	1	0	248 3	3 0
47	500	8	16 2	40 5	97	192	5	28 8	18 1	147	1	0	259 8	2 8
48	492	8	16 2	40 1	98	187	6	29 8	17 6	148	1	1	271 7	2 7
49	484	8	16 2	39 8	99	181	6	30 9	17 1					

The above curves are purely empirical and make no pretense to stating any "laws" of life. They are computed solely for the purpose of accurately and systematically smoothing the raw data of the irregularities consequent upon random sampling and experimental errors.

The complete life tables for *Hydra fusca*, *Agriolimax agrestis*, *Blatta orientalis*, and starved wild (Line 107) *Drosophila* males,

to each individual alive at the beginning of the interval. It is to be understood that in these tables the original experimental observations for *Hydra*, *Agriolimax*, and *Blatta* are accepted as valid on the evidence presented by the authors cited in each case. In the case of *Drosophila* the experimental work was done in this laboratory and we accept full responsibility.

TABLE 2
Complete life table for *Agriolimax agrestis*

AGE	l_x	d_x	$\frac{1000d_x}{(\text{PER } 0.1 \text{ MONTH})}$	e_x	AGE	l_x	d_x	$\frac{1000d_x}{(\text{PER } 0.1 \text{ MONTH})}$	e_x	AGE	l_x	d_x	$\frac{1000d_x}{(\text{PER } 0.1 \text{ MONTH})}$	e_x
months				months	months				months	months				months
0	1000	64	63.9	4.09	5 0	393	16	40.9	2.61	10 0	42	6	142.4	1.12
0.2	936	55	58.8	4.16	5 2	377	16	43.5	2.51	10 2	36	5	147.4	1.08
0.4	881	48	54.2	4.22	5 4	361	17	46.3	2.42	10 4	31	5	152.3	1.05
0.6	833	41	48.8	4.26	5 6	344	17	49.2	2.34	10 6	26	4	157.2	1.03
0.8	792	37	46.0	4.27	5 8	327	17	52.3	2.25	10 8	22	4	162.2	1.00
1 0	755	32	42.5	4.27	6 0	310	17	55.7	2.17	11 0	18	3	167.1	0.97
1 2	723	28	39.4	4.26	6 2	293	18	59.0	2.09	11 2	15	2	172.0	0.95
1 4	695	26	36.7	4.23	6 4	275	17	62.7	2.02	11 4	13	2	177.0	0.93
1 6	669	23	34.2	4.19	6 6	258	17	66.3	1.95	11 6	11	2	181.9	0.90
1 8	646	21	32.3	4.13	6 8	241	17	70.2	1.88	11 8	9	2	186.8	0.88
2 0	625	19	30.6	4.07	7 0	224	17	74.0	1.81	12 0	7	1	191.7	0.86
2 2	606	17	29.3	3.99	7 2	207	16	78.2	1.75	12 2	6	1	196.6	0.84
2 4	589	17	28.3	3.91	7 4	191	15	82.3	1.69	12 4	5	1	201.4	0.82
2 6	572	16	27.6	3.82	7 6	176	15	86.6	1.63	12 6	4	1	206.3	0.80
2 8	556	15	27.3	3.73	7 8	161	15	90.9	1.57	12 8	3	1	211.1	0.79
3 0	541	15	27.2	3.63	8 0	146	14	95.3	1.52	13 0	2	0	215.9	0.77
3 2	526	14	27.4	3.53	8.2	132	13	99.8	1.47	13 2	2	1	220.6	0.75
3 4	512	14	27.9	3.42	8 4	119	13	104.3	1.43	13 4	1	0	225.3	0.74
3 6	498	15	28.7	3.31	8 6	106	11	109.0	1.38	13 6	1	0	230.0	0.72
3 8	483	14	29.7	3.21	8 8	95	11	113.7	1.34	13 8	1	0	234.7	0.71
4 0	469	14	31.0	3.11	9 0	84	10	118.3	1.30	14 0	1	1	239.2	0.69
4 2	455	15	32.5	3.00	9 2	74	9	123.1	1.26					
4 4	440	16	34.4	2.90	9 4	65	8	127.9	1.22					
4 6	424	15	36.3	2.80	9 6	57	8	132.8	1.18					
4 8	409	16	38.5	2.70	9 8	49	7	137.6	1.15					

and starved vestigial *Drosophila* males are given in Tables 1-5 inclusive. In these tables l_x denotes the number alive at the beginning of each age interval; q_x denotes the rate of mortality, i.e., the number dying in the age interval per thousand living at the beginning of the interval; and e_x denotes the expectation of life, i.e., the average length of life remaining

II

In their first paper Pearl and Parker (30) made a rough comparison of *Drosophila* and human life tables, basing their comparison on the equating of one day of fly life to one year of human life. In a later paper Pearl (20) returned to this question, basing his comparison on a superposing of the two curves

so that at least two *biologically equivalent* points coincide. The best two points would be the beginning and the end of the life span. But in the case of *Drosophila* our life tables start with the beginning of *imaginal* life only. The larval and pupal durations are omitted.

Pearl therefore took for his starting point the age "when the instantaneous death rate q_x is a minimum." This was taken to be

the life span cannot be satisfactorily determined; the most straightforward approximation to it is the age at which only some small fraction of the original cohort is left alive. In later papers comparisons by the same method were made by Pearl and Doering (26) of the mortality of *Proales* with those of *Drosophila* and man, and by

TABLE 3
Complete life table for *Blatta orientalis*

AGE	l_x	d_x	$1000q_x$	$\frac{d_x}{l_x}$	AGE	l_x	d_x	$1000q_x$	$\frac{d_x}{l_x}$	AGE	l_x	d_x	$1000q_x$	$\frac{d_x}{l_x}$
days					days					days				
0	1000	1	1 1	40 9	25	902	15	16 1	18 3	50	232	25	111 0	6 4
1	999	1	1 0	39 9	26	887	16	18 0	17 6	51	207	25	117 3	6 1
2	998	1	0 7	39 0	27	871	17	19 9	16 9	52	182	22	123 9	5 8
3	997	0	0 6	38 0	28	854	19	22 0	16 2	53	160	21	130 7	5 6
4	997	1	0 6	37 0	29	835	20	24 3	15 6	54	139	19	137 6	5 4
5	996	1	0 5	36 0	30	815	22	26 7	14 9	55	120	18	144 9	5 1
6	995	0	0 6	35 1	31	793	23	29 3	14 3	56	102	15	152 4	4 9
7	995	1	0 6	34 1	32	770	25	32 0	13 8	57	87	14	160 1	4 7
8	994	1	0 7	33 1	33	745	26	34 8	13 2	58	73	12	168 0	4 5
9	993	1	1 0	32 1	34	719	27	37 8	12 6	59	61	11	176 3	4 3
10	992	1	1 3	31 2	35	692	28	41 0	12 1	60	50	9	184 7	4 2
11	991	1	1 6	30 2	36	664	30	44 3	11 6	61	41	8	193 4	4 0
12	990	2	2 0	29 2	37	634	30	47 9	11 1	62	33	7	202 2	3 8
13	988	3	2 5	28 3	38	604	31	51 5	10 7	63	26	5	211 4	3 7
14	985	3	3 2	27 4	39	573	32	55 4	10 2	64	21	5	220 8	3 5
15	982	4	3 9	26 5	40	541	32	59 4	9 8	65	16	4	230 4	3 4
16	978	4	4 6	25 6	41	509	32	63 7	9 4	66	12	3	240 3	3 3
17	974	6	5 5	24 7	42	477	33	68 1	9 0	67	9	2	250 3	3 1
18	968	6	6 4	23 8	43	444	32	72 8	8 6	68	7	2	260 6	3 0
19	962	7	7 5	23 0	44	412	32	77 6	8 2	69	5	1	271 2	2 9
20	955	8	8 6	22 1	45	380	31	82 6	7 9	70	4	1	281 9	2 8
21	947	10	9 9	21 3	46	349	31	87 9	7 6	71	3	1	292 9	2 7
22	937	10	11 2	20 5	47	318	30	93 3	7 2	72	2	1	304 1	2 6
23	927	12	12 8	19 8	48	288	28	99 0	6 9	73	1	0	315 5	2 5
24	915	13	14 3	19 0	49	260	28	104 9	6 6	74	1	0	327 1	2 4
										75	1	1	338 9	2 3

age 1 day for *Drosophila* and age 12 years for man. As an approximation to the indeterminate upper end of the life span was taken the age "at which there is left but one survivor out of 1,000 starting at age 1 day for *Drosophila* and age 12 years for white males." There is, of course, an arbitrary element in this, as in most approximations. The exact upper end of

Pearl and Parker (35) of wild type and vestigial *Drosophila* with man and with *Teles polyphemus*.

This method of comparing life tables of different organisms has been criticised by Greenwood (14) on the ground that the sampling error will be high for the age at which there is left one survivor out of a thousand. Brownlee (5) assumed that

TABLE 4
Life table for starved wild (Lens 107) Drosophila melanogaster

AGE	l_x	d_x	$1000l_x$	σ_x	AGE	l_x	d_x	$1000l_x$	σ_x	AGE	l_x	d_x	$1000l_x$	σ_x
hours				hours	hours				hours	hours				hours
0	1000	1	0 7	44 1	25	980	2	1 5	19 7	50	158	38	237 5	3 5
1	999	0	0 7	43 1	26	978	1	1 8	18 7	51	120	29	245 9	3 4
2	999	1	0 7	42 1	27	977	2	2 1	17 8	52	91	23	252 3	3 3
3	998	1	0 7	41 2	28	975	3	2 6	16 8	53	68	18	257 2	3 3
4	997	0	0 7	40 2	29	972	3	3 3	15 9	54	50	13	260 9	3 3
5	997	1	0 7	39 2	30	969	4	4 2	14 9	55	37	10	263 7	3 2
6	996	1	0 7	38 3	31	965	6	5 4	14 0	56	27	7	265 8	3 2
7	995	1	0 7	37 3	32	959	6	7 1	13 0	57	20	5	267 3	3 2
8	994	0	0 7	36 3	33	953	9	9 4	12 1	58	15	4	268 4	3 2
9	994	1	0 7	35 3	34	944	12	12 4	11 2	59	11	3	269 2	3 2
10	993	1	0 7	34 4	35	932	15	16 4	10 4	60	8	2	269 8	3 2
11	992	0	0 7	33 4	36	917	20	21 8	9 5	61	6	2	270 2	3 2
12	992	1	0 7	32 4	37	897	26	28 8	8 7	62	4	1	270 6	3 2
13	991	1	0 8	31 4	38	871	33	37 8	8 0	63	3	1	270 8	3 2
14	990	1	0 8	30 5	39	838	41	49 0	7 3	64	2	0	271 0	3 2
15	989	1	0 8	29 5	40	797	50	62 8	6 6	65	2	1	271 1	3 2
16	988	0	0 8	28 5	41	747	59	79 1	6 0	66	1	0	271 2	3 2
17	988	1	0 8	27 5	42	688	68	97 8	5 5	67	1	0	271 3	3 2
18	987	1	0 9	26 5	43	620	73	118 2	5 1	68	1	1	271 3	3 2
19	986	1	0 9	25 6	44	547	76	139 5	4 7					
20	985	1	0 9	24 6	45	471	76	160 5	4 3					
21	984	1	1 0	23 6	46	395	71	180 5	4 1					
22	983	1	1 1	22 6	47	324	64	198 5	3 9					
23	982	1	1 2	21 7	48	260	56	214 0	3 7					
24	981	1	1 3	20 7	49	204	46	227 0	3 6					

TABLE 5
Life table for starved vestigial (mutans) Drosophila melanogaster

AGE	l_x	d_x	$1000l_x$	σ_x	AGE	l_x	d_x	$1000l_x$	σ_x	AGE	l_x	d_x	$1000l_x$	σ_x
hours				hours	hours				hours	hours				hours
0	1000	0	0 02	44 8	25	987	3	2 9	20 1	50	225	49	216 9	3 4
1	1000	0	0 03	43 8	26	984	3	3 5	19 2	51	176	41	235 2	3 3
2	1000	0	0 03	42 8	27	981	5	4 3	18 2	52	135	34	251 8	3 1
3	1000	0	0 04	41 8	28	976	5	5 2	17 3	53	101	27	266 6	3 0
4	1000	0	0 05	40 8	29	971	6	6 3	16 4	54	74	21	279 2	2 9
5	1000	0	0 05	39 8	30	965	7	7 6	15 5	55	53	15	290 0	2 8
6	1000	0	0 07	38 8	31	958	9	9 2	14 6	56	38	12	299 0	2 7
7	1000	0	0 09	37 8	32	949	11	11 2	13 7	57	26	8	306 5	2 7
8	1000	0	0 1	36 8	33	938	12	13 6	12 9	58	18	5	312 6	2 6
9	1000	1	0 1	35 8	34	926	16	16 4	12 1	59	13	4	317 4	2 6
10	999	0	0 1	34 8	35	910	18	19 9	11 2	60	9	3	321 6	2 6
11	999	0	0 2	33 8	36	892	21	24 1	10 5	61	6	2	324 8	2 5
12	999	0	0 2	32 8	37	871	26	29 1	9 7	62	4	1	327 4	2 5
13	999	0	0 3	31 8	38	845	29	35 1	9 0	63	3	1	329 4	2 5
14	999	1	0 3	30 8	39	816	35	42 3	8 3	64	2	1	331 2	2 5
15	998	0	0 4	29 8	40	781	40	50 8	7 6	65	1	0	332 5	2 5
16	998	1	0 5	28 8	41	741	45	60 9	7 0	66	1	0	333 6	2 5
17	997	0	0 6	27 9	42	696	50	72 6	6 4	67	1	1	334 5	2 5
18	997	1	0 7	26 9	43	646	56	86 1	5 9					
19	996	1	0 9	25 9	44	590	60	101 4	5 4					
20	995	1	1 1	24 9	45	530	62	118 5	5 0					
21	994	1	1 3	23 9	46	468	65	137 1	4 6					
22	993	2	1 6	23 0	47	403	63	156 9	4 2					
23	991	2	2 0	22 0	48	340	60	177 1	3 9					
24	989	2	2 4	21 1	49	280	55	197 4	3 7					

the imaginal life of *Drosophila* is equivalent to the total postnatal life of man.

Feeling the inadequacy of Pearl's earlier method of comparing the order of dying with respect to age of different organisms, not only because of the defect pointed out by Greenwood but also for other reasons, we have sought to find a more trustworthy method. We believe that it is available in the fact that the method devised by Pearl (22) for representing relative variability may be applied to the comparison of life tables of different organisms, each of which differs in the absolute duration of its life span. Each table, on

TABLE 6
Mean duration for life tables discussed

LIFE TABLES	MEAN DURATION OF LIFE
<i>Drosophila</i> , Normal wild type ♂♂	45 81 days
<i>Drosophila</i> , Vestigial ♂♂	14 13 days
<i>Drosophila</i> , Normal wild type, starved ♂♂	44 09 hours
<i>Drosophila</i> , Vestigial, starved ♂♂	44 77 hours
<i>Proales decipiens</i> . . .	5 95 days
<i>Hydra fusca</i>	54 89 days
<i>Blatta orientalis</i>	40 89 days
<i>Agrostis agrestis</i> .	4 12 months
Mice (Hill's data)	636 5 days
Automobiles	7 04 years

this plan, may be presented in terms, not of years or of days or any other absolute time unit, but of percentage deviations from the mean duration of life. The values of the mean durations of life for the organisms compared are given in Table 6.

This method of comparison will not be subject to Greenwood's criticism, since the mean is one of the most efficient of statistics. In its determination all the observed data play a part. The mean or average is, of course, basically a statistical concept—an abstraction used to define, in part, the characteristics of a group. But it has long been an accepted biological generalization that the mean may be taken more satisfactorily than any other

abstraction yet suggested as representing the *type* of the species. There would seem to be no reason why this generalization should not be as valid for duration of life as for other measurable characters. The mean duration of life for species *A* tells us how long the individuals of that species *typically* live. This information, in common sense and reason, is surely comparable and has the same meaning from species to species.

Table 7 gives, for ages expressed as percentage deviations from the mean duration of life (a) the survivorship distributions (l_x) of the various organisms, together with Griffin's (15) automobile life table; (b) the death distributions (d_x) of the same groups; and (c) the death rate distributions (1000 q_x per 20 percent deviation from the mean duration of life) of the same groups.

The nature and meaning of the results embodied in Table 7 will be clearer if they are exhibited in graphic form. This is done in Figs. 1, 3, and 5.

III

Let us examine first the survivorship curves of Table 7 and Fig. 1. These give the number of survivors at the same relative ages out of each 1000 born (or starting their life histories) together. It is at once clear that the ten curves fall naturally into three groups or classes. These groups we have called respectively the rectangular, intermediate, and diagonal. They represent different *types* of life tables, or, otherwise stated, different types of distribution in relative time of the relative number of survivors. The first of these types, the *rectangular*, in the *theoretical limiting case* describes the situation where all the individuals in a cohort are born at the same time, live for the same length of time, and all die at the same instant of time. The l_x curve for such a cohort

TABLE 7

Survivorship (l_x), death (d_x), and death rate (10000 per 10 per cent deviation) distributions expressed as percentage deviations from mean duration of life

SPECIES AND DISTRIBUTION	PERCENTAGE DEVIATIONS FROM MEAN DURATION OF LIFE															
	-8	-6	-4	-2	0	+2	+4	+6	+8	+10	+12	+14	+16	+18	+20	+22
<i>Drosophila</i> (Wild type) Lsne 107) ♂♂																
Survivorship (l_x)	1000	988	945	867	741	556	322	118	19	1	—	—	—	—	—	—
Death (d_x)	12	43	78	126	185	234	204	99	18	1	—	—	—	—	—	—
Death rate (q_x)	12	44	83	145	250	421	634	839	947	1000	—	—	—	—	—	—
<i>Drosophila</i> (Vestigial) ♂♂																
Survivorship (l_x)	1000	993	924	795	635	469	323	211	132	84	49	30	18	11	5	2
Death (d_x)	7	69	129	160	166	146	112	79	52	31	19	12	7	6	3	2
Death rate (q_x)	7	69	140	201	261	311	347	374	394	387	388	400	389	345	600	1000
<i>Drosophila</i> (Starved wild type) ♂♂																
Survivorship (l_x)	1000	991	981	967	914	537	71	5	—	—	—	—	—	—	—	—
Death (d_x)	9	10	14	53	377	466	66	5	—	—	—	—	—	—	—	—
Death rate (q_x)	9	10	14	55	412	868	930	1000	—	—	—	—	—	—	—	—
<i>Drosophila</i> (Starved vestigial) ♂♂																
Survivorship (l_x)	1000	1000	997	981	895	544	81	3	—	—	—	—	—	—	—	—
Death (d_x)	0	3	16	86	351	463	78	3	—	—	—	—	—	—	—	—
Death rate (q_x)	0	3	16	88	392	851	963	1000	—	—	—	—	—	—	—	—
<i>Agrostismax agrestis</i>																
Survivorship (l_x)	1000	787	664	583	519	460	398	330	259	190	129	81	46	24	11	5
Death (d_x)	213	123	81	64	59	62	68	71	69	61	48	35	22	13	6	3
Death rate (q_x)	213	157	122	108	114	136	171	215	266	320	375	429	481	530	576	617
<i>Hydra fusca</i>																
Survivorship (l_x)	1000	875	747	629	526	440	367	302	242	182	119	59	18	3	—	—
Death (d_x)	125	128	118	103	86	73	65	60	60	63	60	41	15	3	—	—
Death rate (q_x)	125	146	158	164	163	166	177	199	248	346	504	695	833	1000	—	—
<i>Proales decipiens</i>																
Survivorship (l_x)	1000	1000	996	967	849	543	147	1	—	—	—	—	—	—	—	—
Death (d_x)	0	4	29	118	306	396	146	1	—	—	—	—	—	—	—	—
Death rate (q_x)	0	4	29	122	360	729	993	1000	—	—	—	—	—	—	—	—
<i>Blatta orientalis</i>																
Survivorship (l_x)	1000	994	977	908	752	513	258	83	15	1	—	—	—	—	—	—
Death (d_x)	6	17	69	156	239	255	175	68	14	1	—	—	—	—	—	—
Death rate (q_x)	6	17	71	172	318	497	678	819	933	1000	—	—	—	—	—	—
<i>Mus</i> (Hill's data)																
Survivorship (l_x)	1000	988	961	901	775	548	247	40	1	—	—	—	—	—	—	—
Death (d_x)	12	27	60	126	227	301	207	39	1	—	—	—	—	—	—	—
Death rate (q_x)	12	27	62	140	293	549	838	975	1000	—	—	—	—	—	—	—
Automobiles																
Survivorship (l_x)	1000	979	912	801	654	488	325	191	94	38	12	3	—	—	—	—
Death (d_x)	21	67	111	147	166	163	134	97	56	26	9	3	—	—	—	—
Death rate (q_x)	21	68	122	184	254	334	412	508	596	684	750	1000	—	—	—	—

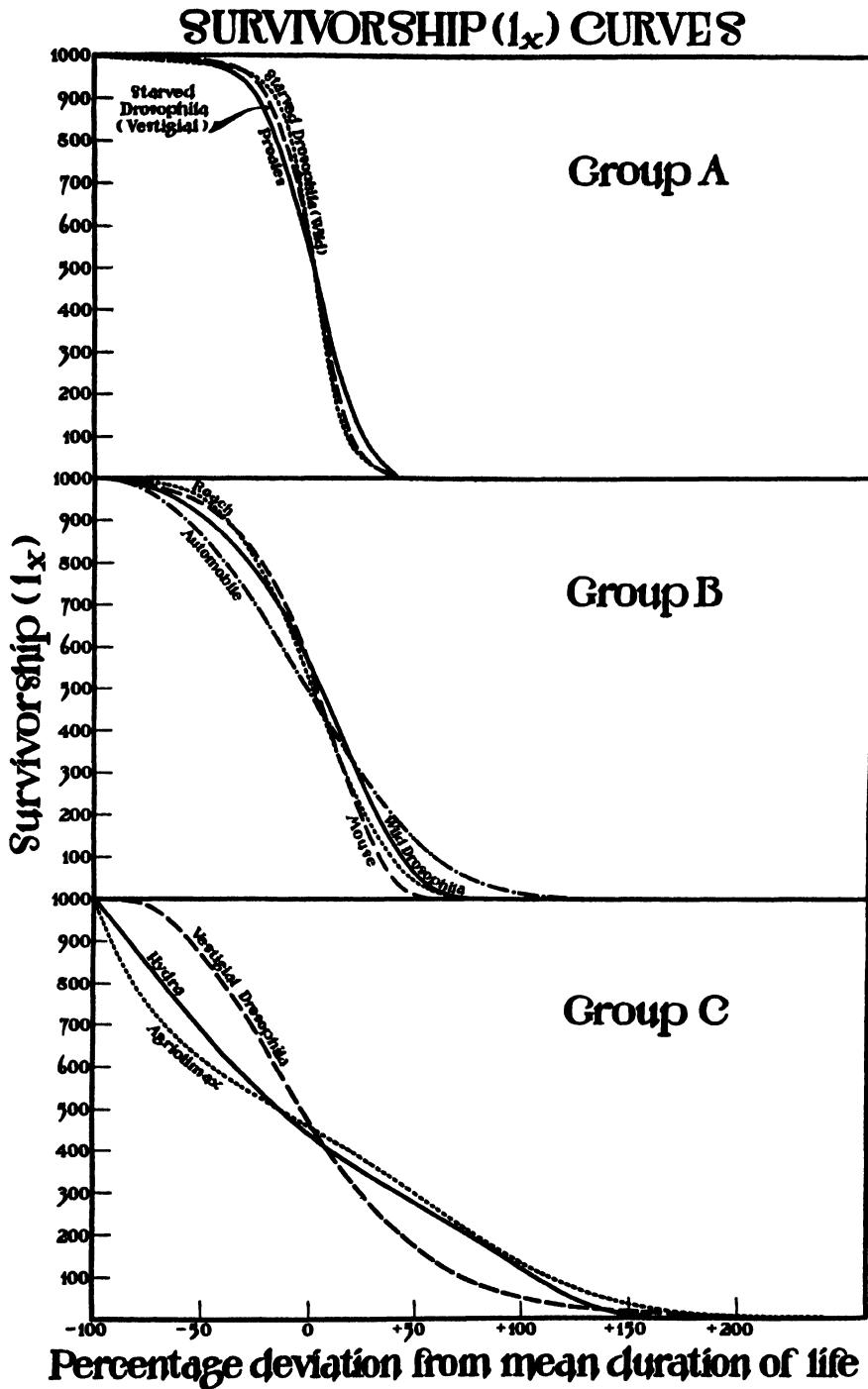


FIG. 1. SURVIVORSHIP CURVES FOR VARIOUS SPECIES OF ANIMALS AND FOR AUTOMOBILES ON A RELATIVE TIME BASE
 For each form represented the mean duration of life is taken as 100 percent on the abscissal scale, and all other ages (time duration) are expressed as percentage deviations (plus or minus) from this mean.

would be two straight lines at right angles to each other, forming the top and right side of a rectangle. This theoretical type of life curve is approached, though not precisely realized by the three curves in the upper panel (Group A) of Fig. 1, namely those for *Proales* and starved *Drosophila* (both wild type and vestigial). In the theoretical limiting case of this type the mean duration of life of the individuals of the species and the span of life of the species are identical. In the three actual examples here presented, with all the errors of sampling and experimental fluctuations necessarily involved, this theoretical ideal is fairly closely approached, the upper end of the life span standing to the mean duration of life roughly as only 140:100 in relative age.

An *intermediate* type of life curve is represented in the present material by four curves, those for the mouse, the roach *Blatta orientalis*, wild type *Drosophila*, and the automobile. The common characteristic of the l_x line for this type of life curve is that it is a smoothly flowing curve concave to the time axis in the first moiety of the life cycle and convex to the same axis in the last moiety, in all the examples here presented, and in most other cases. It presents a form that might be produced by stretching the A type (rectangular) l_x line along the abscissal (time) axis. The total life span, in terms of relative age, is greater relative to mean duration of life than in Type A, the ratio for the present examples being, as an average, roughly 185:100. It appears to represent the characteristic order of wearing out of man-made machines, as exemplified by Griffin's automobile life curve here depicted, but even here there is also theoretically a quasi-"genetic" element, since more expensive types of automobiles are supposedly made of better materials than the cheaper types, and on

that account should tend to wear longer. Actually Griffin's data show a distinct difference in the l_x lines for Fords and "all other" cars. The wearing (or dying) out begins slowly at first, then achieves a maximum of rapidity, and finally slows up again with the obsolescence of the "tough" machines that stubbornly hang on and continue to function.

The *diagonal* (when plotted on an arith-log scale) type of survivorship curves has an approximately constant death-rate until near the end of the life span (in the theoretical limiting case). In the present material the fresh water polyp *Hydra fusca*, the slug *Agriolimax agrestis*, and the *Drosophila* mutant vestigial approach this type of order of dying out. These forms have as common characteristics, first, an approach to a constant death-rate at all ages, until near the end of the life span, and, second, a very wide ratio of total life span to mean duration of life. On the average, for these three forms, this ratio is 300:100, or, in other words, some individuals live three times as long as the average of the population. If man had this characteristic the upper limit of his life span would be around 175 to 180 years instead of around 100 years as it is.

The types of survivorship curves illustrated in Fig. 1 do not completely cover the range of theoretical possibilities in the case. These theoretical possibilities are somewhat crudely set forth graphically in Fig. 2.

From Fig. 2 it appears that there are two theoretically possible types of rectangular life curves. One of these, the *negatively skew rectangular type*, labelled A, is the one already illustrated in Fig. 1, with three examples. The other, or *positively skew rectangular type*, labelled D, is not illustrated in Fig. 1 by an actual example, because as yet we know of no living organism that very closely ap-

proaches this type in the distribution of its normal survivorship. The nearest approach to this type that we know of, and this is admittedly not a very close approach, is the life table for human beings in India [See Glover (11) p. 261, or a reproduction of this figure in Pearl (25), p. 245]. In this type of life curve there is an extremely heavy mortality immediately after birth (or the beginning of life) that

tion as practiced by live-stock breeders. For example, many years ago when we were operating an experimental poultry plant at the Maine Agricultural Experiment Station we might, in a given year, hatch from 3000 to 5000 chicks, and in three months or so kill off (or otherwise eliminate from the cohort) all but 500 or 600 to carry over the next winter. These selected birds would, if permitted, go on

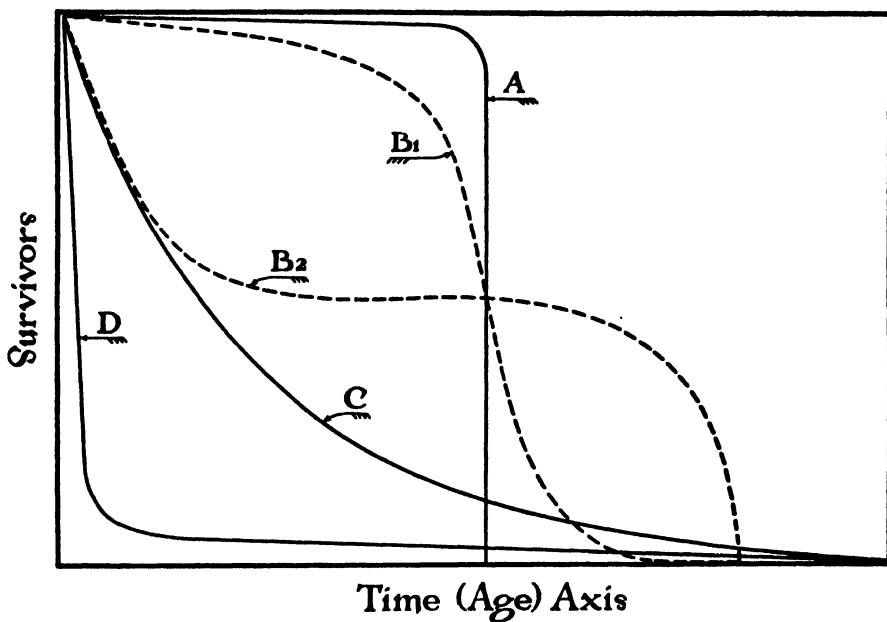


FIG. 2. DIAGRAM TO ILLUSTRATE THE THEORETICALLY POSSIBLE DISTINCT TYPES OF LIFE CURVES. EXPLANATION IN TEXT

eliminates all but a small fraction of the whole cohort. These few survivors must be regarded as biologically differentiated from those eliminated, because they have the power to go on living, with only a very slight mortality, to the completion of a relatively long span of life. This positively skew rectangular type is the sort of curve that would represent the most extreme type of natural selection. Something closely resembling it is frequently brought about by artificial selec-

tion as practiced by live-stock breeders. For example, many years ago when we were operating an experimental poultry plant at the Maine Agricultural Experiment Station we might, in a given year, hatch from 3000 to 5000 chicks, and in three months or so kill off (or otherwise eliminate from the cohort) all but 500 or 600 to carry over the next winter. These selected birds would, if permitted, go on

that do survive have a long life span. Szabó (44) cites as example of this general type of curve that furnished by the mortality of forest trees, and illustrates it specifically by the data of Fekete (9) on the oak. But the curve as pictured by him is far from an extreme illustration of the type.

From Fig. 2 it seems clear that what we called group B (*Intermediate*) is really only a sub-type, now labelled B_1 of our Type C. Sub-type B_1 is represented in Fig. 1 by the curves in group B, and theoretically best by the curve for vestigial *Drosophila* in Panel C. Corresponding to sub-type B_1 there plainly should be, as drawn, a sub-type B_2 , convex to the time axis in the first part of the life cycle, and concave to the same axis in the later part of the cycle. An actual example of a fair approximation of this sub-type B_2 is given by the *Agriolimax* curve in Fig. 1. The ordinary human life curve is a considerably distorted example of this B_2 type.

Finally the curve for *Hydra* furnishes the nearest approach yet discovered to the theoretically perfect Type C, the type in which the l_x line when plotted to arithlog coördinates would be a diagonal line, straight until near the upper end of the life span; and, since it is really a decreasing exponential, when plotted to arithmetic coördinates, a gently curving diagonal line convex to the base.

We turn next to the consideration of the death curves (d_x) of Table 7. These are shown graphically in Fig. 3.

The discussion of the death curves may well be prefaced by the remark that, with the exception of the automobile, in all the forms dealt with in Table 7, d_x (in the true actuarial sense) is *directly* observed, and is in fact the basic observation from which all the other life table functions are derived. Each individual in each group is observationally followed

throughout its life, from its birth to its death.

We see at once from Fig. 3 that the death curves are essentially *frequency curves of variation* relative to time of dying. They show the distribution of individual variations in the duration of life from birth to death. They differ among themselves in respect of

- a. Scatter (degree of inter-individual variation), and
- b. Skewness.

In the case of the group A curves of Fig. 3 the d_x curves exhibited a very small degree of variation; their two limbs are comparatively close together, and in general they are rather sharply peaked, unimodal, "sugar loaf" or "cocked hat," frequency curves. Furthermore they are negatively skew, tailing off more gradually, on the whole, towards the left than towards the right. The mortality in the early part of the life span is very slight. In other words, virtually all the dying is concentrated at the extreme old age end of the life curve. Curves of this type are logically capable of being interpreted biologically as the consequences of *either*:

1. All mortality the end result of senescence (wearing out) of the individual, this senescent process going on at virtually the same time rate and to the same degree in each individual of the species, or
2. All mortality the result of a lethal agent of environmental origin, so powerful that its ability to kill considerably transcends individual variations in power to resist its action, with the result that it kills all the individuals at the same time. Thus, for example, if a somewhat greater than minimum lethal dose of a poison were given to all the individuals of a cohort born at the same time the result would be a life curve of the A type. Precisely this sort of thing is what did happen in the case of two starved *Drosophila* curves,

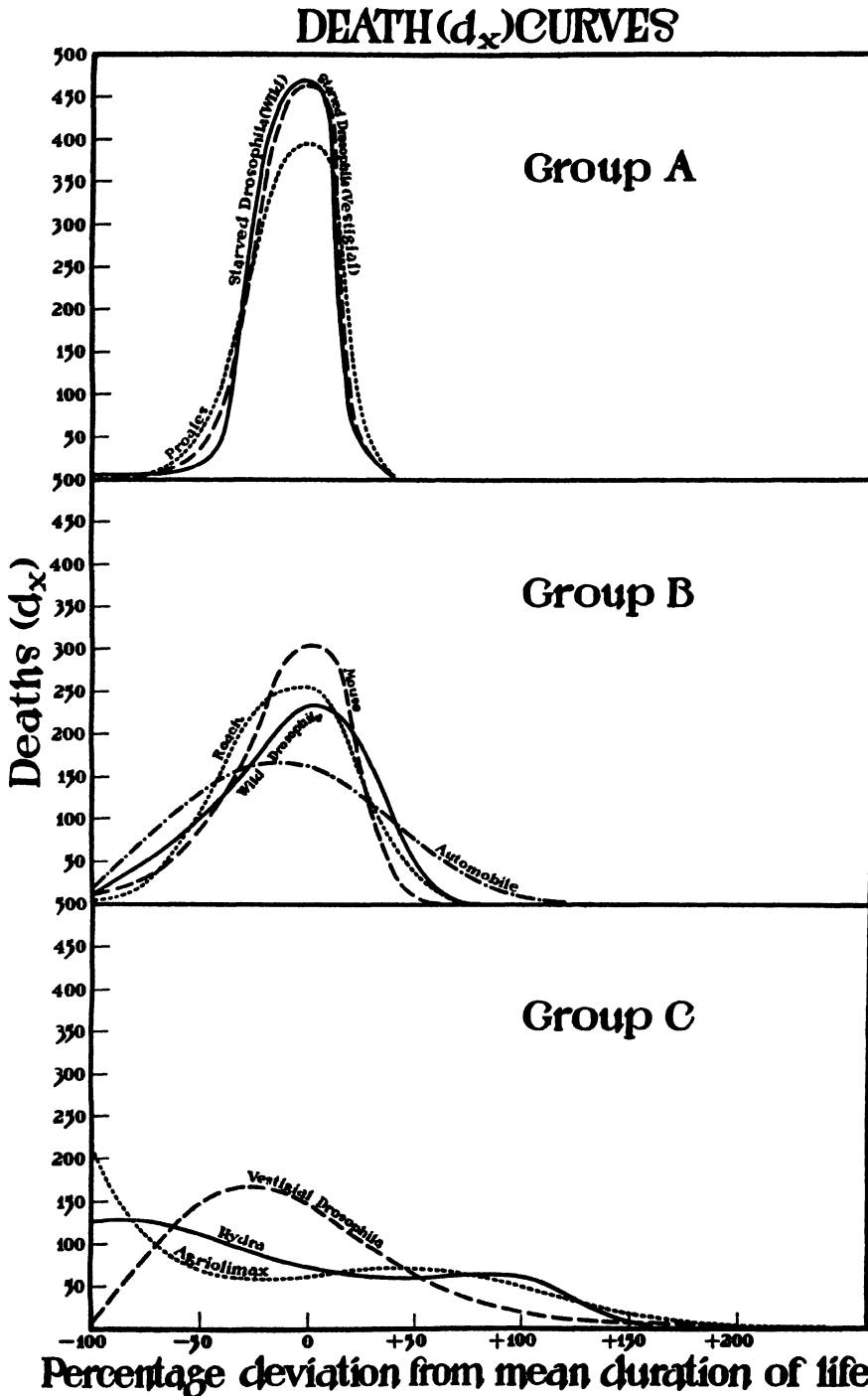


FIG. 3. DEATH CURVES FOR VARIOUS SPECIES OF ANIMALS AND FOR AUTOMOBILES ON A RELATIVE TIME BASE. For each form represented the mean duration of life is taken as 100 percent on the abscissal scale, and all other ages (time duration) are expressed as percentage deviations (plus or minus) from this mean.

starvation taking the place in these cases of an administered poison. Again a universally fatal epidemic disease attacking only individuals within a narrow age range would produce the A type of death curve.

3. All mortality the resultant of some combined action of 1 and 2 as above.

4. All mortality the resultant solely of a substantially uniform genetic constitution of all the individuals of the cohort, specific in respect of duration of life. If all the individuals of a cohort were supposed equipped with a single lethal gene timed or set to kill at a particular chronological age of the individual the resultant life curve would be of the A type. So also it would be if instead of bearing a single gene such as that postulated they all had a substantially uniform combination of n genes with the same lethal power.

Unfortunately the available data are neither sufficient nor adequate to determine which of the stated alternatives is the "correct" or "ruling" one in the premises, if there is any single one for all species. Together, however, they would seem fairly to cover the permissible range of biological possibilities in the case, unless someone should wish to postulate a final fifth combination of 1, 2 and 4. It is our view, subject to correction by further evidence, that there is probably no one and invariable single scheme or plan of causation of the distribution of variation in the order of dying, common even to all species having the same type of mortality table.

One definite point seems clear; the evidence from the observed cases as well as theoretical considerations, plainly indicate that "accident" cannot normally play any significant part in the mortality leading to the A type of life curve. One other point worth noting is that while in the case of the starved *Drosophila* curves

of the A type the situation postulated in paragraph 2 above is *sufficient* to produce the observed result without an additional factor, there is no evidence whatever that the same is true for the substantially identical *Proales* curve. In fact all the evidence, direct or inferential, for *Proales* is in quite the contrary direction. In short it seems clearly established, even on the meager available data, that while a lethal environmental agent *will* produce a Type A life curve, such curves are not necessarily produced in this way but *may* arise in nature from quite other causes.

In the case of the group B (*Intermediate*) d_s curves the degree of scatter (inter-individual variation in time of dying) is plainly greater than in the A group. The curves are less sharply peaked. Some of them are negatively skew (Wild type *Drosophila*), others are positively skew (Automobile), while still others are very nearly symmetrical (*Blatta*). But where the curves are significantly skew, the degree of the skewness is less marked than in Group A. In all of the B group curves, furthermore, the distributions are uni-modal, just as was the case in the A group.

Any attempt at a biological interpretation of the B group death curves will recognize, first, the great probability—indeed practical certainty—that a larger number of causal factors are together concerned in bringing about their characteristic form than is the case in the A group. The greater inter-individual variation in age at death in and of itself indicates this. Furthermore we know that accidental deaths are, in the B group, beginning to amount to a significant portion of the total mortality. In the second place the postulate of a single lethal environmental factor operating would seem to have no cogency in accounting for the distribution of mortality in the B group. The individuals are widely scattered in their time

of dying, and the peak of mortality is neither at nor near the end of the life span. As regards senescence and genetic constitution, it would seem probable that insofar as either of these is in operation it must be less uniform in its rate of action from individual to individual, or less homogeneous from individual to individual, in producing B type than A type death curves.

which the deaths occurred has been so reduced near the extreme upper end of the life span that it is no longer possible for the constant number of deaths per unit of time to occur.

Turning from the actual examples of Table 7 let us consider briefly what are the theoretical limiting forms of d_x curves for our basic types of life curves A, B₁, B₂, C, and D discussed in the preceding

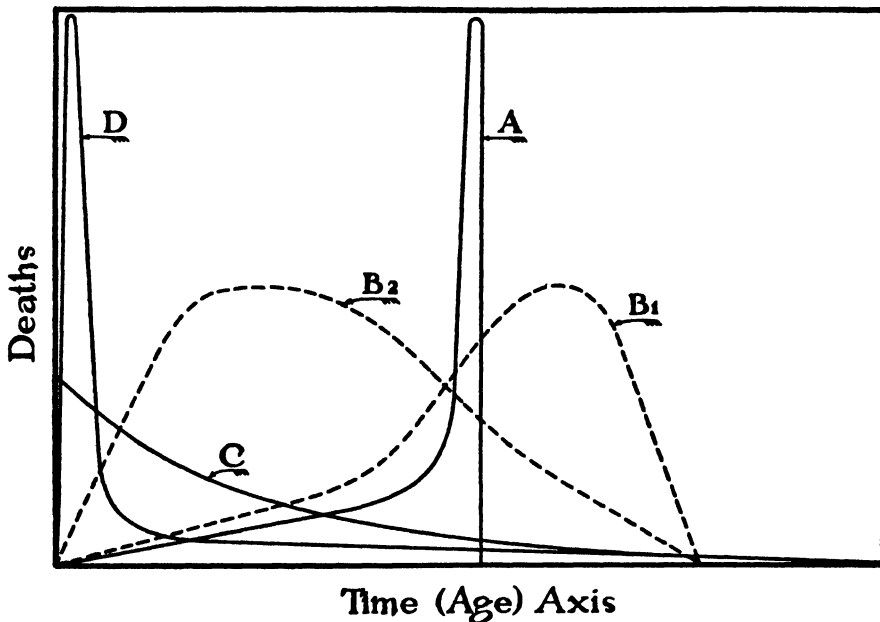


FIG. 4. DIAGRAM ILLUSTRATING THEORETICAL FORMS OF d_x CURVES FOR FOUR BASIC TYPES OF LIFE CURVES

The characteristics of the group C curves of Fig. 3 are, first of all great inter-individual variability in time of dying—in fact relatively enormous scatter—and a great degree of positive skewness in the cases of *Agriolimax* and vestigial *Drosophila*. The *Hydra* curve approaches the rectangular or straight horizontal type of frequency distribution, indicating in this case a practically constant absolute number of deaths per unit of time over the greater part of the life span, until in fact the numbers of living in the pool from

section. These limiting forms are shown graphically in Fig. 4.

We have represented the d_x curves for Types A and D as extremely skew "cocked-hat" curves. It is at least as probable that at the limits these are J-shaped curves, with, of course, a finite maximum ordinate. The C type curve is an extremely interesting one, for it depicts a situation where the age of the individual has *per se* nothing to do with the probability of its dying. By inference these are forms in which neither

senescence nor genetic constitution play any significant rôle. That there are such forms has been ably argued by Bidder (3, 4). Mortality in such cases is wholly a consequence of the direct action of environmental forces, and is "accidental" from the standpoint of the organism. Bidder argues that forms behaving relative to mortality in this way are characteristically aquatic organisms and that the absence of senescence is associated with never ending growth.

The d_x curves for Types B₁ and B₂ are seen from Fig. 4 to be intermediate, in respect of both variation spread and skewness, between Types A and D on the one hand, and C on the other.

IV

In Fig. 5 are presented the death-rate or q_x curves from the data of Table 7.

Since a death rate is essentially only the ratio between the number of deaths occurring in a given time interval and the number of living in the same interval, it necessarily follows that the forms of the curve in Fig. 5 are completely determined by those of Figs. 1 and 3. The most cursory examination of Fig. 5 shows that the essential change in the form of the q_x curves as we pass from Group A through B to C is generally *decreasing* rapidity of slope upward of the lines, or, conversely, an increasing tendency of the q_x line to approach horizontality until the upper end of the life span is nearly approached.

Theoretically the q_x curve, from a starting value at birth, may either (a) generally ascend, (b) stay approximately horizontal, (c) generally descend, or (d) pursue a sinuous course, falling in the first part of the life span and rising in the latter part. Actually the *general* trend of all q_x curves so far observed is ascending either throughout the whole life span or in its later portions. Man and *Agriolimax*

are the only forms so far quantitatively studied in which the q_x curve definitely descends even during the first part of the life span. In *Hydra* the curve is very nearly horizontal for the whole first half of the life span. For purely arithmetic reasons, as has been intimated earlier in this paper, the q_x curve must necessarily ascend towards the end of the life span in any species with a finite life span (that is, in which the individuals composing it are not immortal). The point in the life cycle where the q_x curve that has been previously descending will necessarily begin to ascend is where the second successive age period contains only one death. To make the curve continue to descend after the first period in which only one death has occurred it would be necessary to have a fraction of one death. But deaths are and must be counted in integers. In actual fact and in nature, of course, all known death rate curves begin ascending long before the deaths in a given time interval are reduced to one.

V

Is it possible now to present a rational and complete theory of natural death and its distributions relative to time (age)? In our opinion it is not. The data available to build upon are far too meager. Counting in man, we have reasonably complete life tables for only some seven species of animals, and these few species differ widely among themselves in respect of their order of dying out. All that we can sensibly hope to do in the present state of knowledge, as it seems to us, is to carry the rational biological analysis of the problem as far as possible, and then await more data before going further. This we shall now try briefly to do. The views to be developed combine some features of theories that have been advanced by various workers. While for the sake

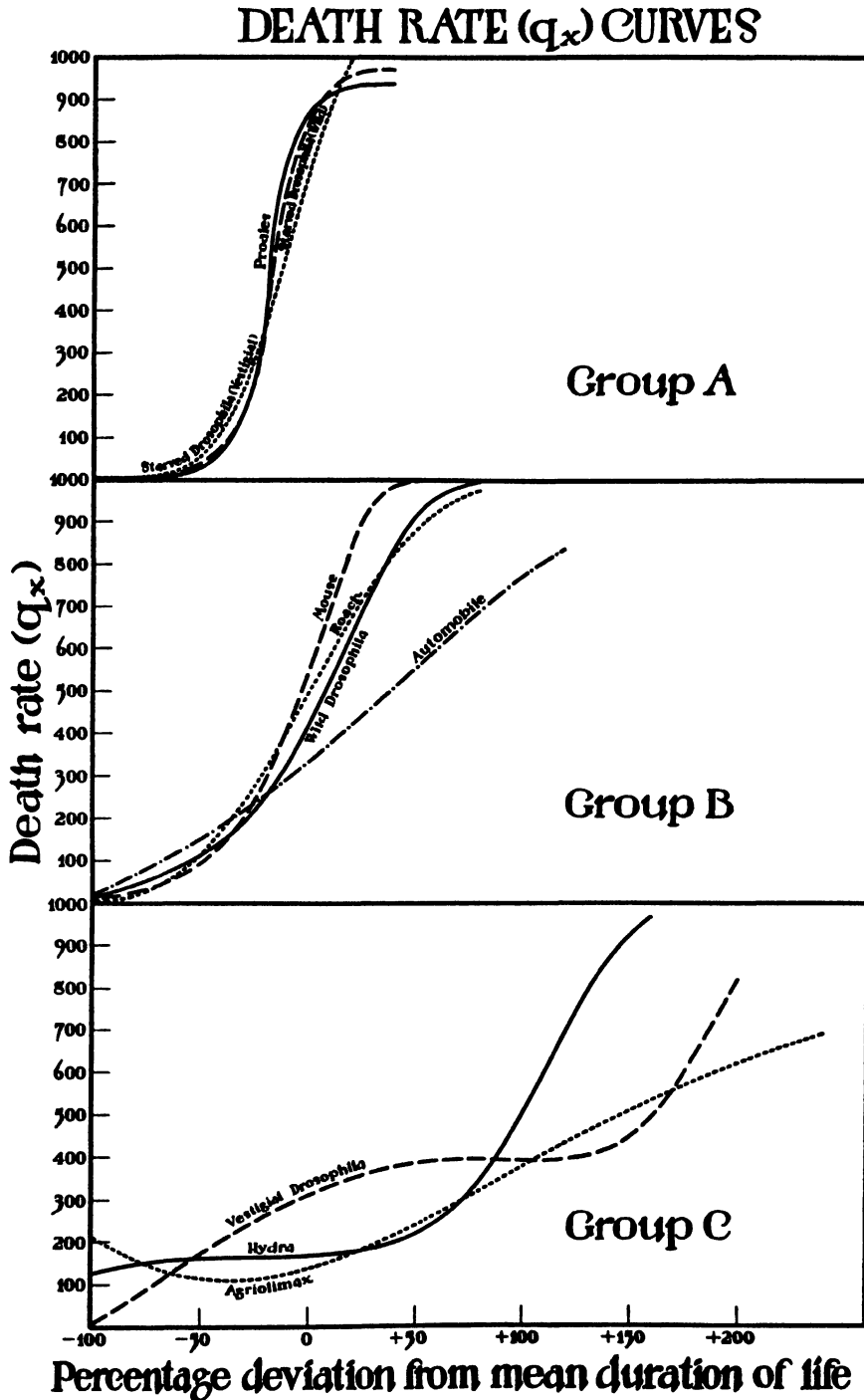


FIG. 5. DEATH RATE CURVES FOR VARIOUS SPECIES OF ANIMALS AND FOR AUTOMOBILES ON A RELATIVE TIME BASE
 For each form represented the mean duration of life is taken as 100 percent on the abscissal scale, and all other ages (time duration) are expressed as percentage deviations (plus or minus) from this mean.

of clarity and brevity the form of statement is in form dogmatic at certain points, there is no intention of dogmatism. The whole statement of the case is regarded by us at present in some degree hypothetical, and is to be so understood by the reader.

It would seem to be a fair statement that in all that is known at present about the occurrence of natural death and its distribution relative to time (age) there are concerned various combinations of five major *factors*, as wholes or in part.

These factors are:

A. *Endogenous senescence*, the wearing out and functional slowing down of the organism in consequence of its internal functioning. This process appears to be primarily a consequence of specialization of structure (and function) in metazoa (21) and perhaps may not occur to a significant degree in forms that never stop growing (Bidder).

B. *Exogenous senescence*, the wearing out and slowing down of the organism consequent upon the injuries inflicted by environmental buffeting, infectious diseases, etc., that in each individual case are not lethal, but that leave behind in each case some permanent damage; such injuries being necessarily cumulative with time.

Observationally it is not always easy to distinguish between endogenous and exogenous senescence upon the basis solely of the objective effects observable in the body. Many of the objective functional and structural phenomena of senescence that begin at (or possibly before) birth and continue till death, such as protoplasmic hardening (the "hysteresis" effect especially emphasized by Růžička and his students (42)), the progressive age change in time required for complete anaesthesia in *Drosophila* (38), or the gradual lowering of the metabolism rate with age, especially emphasized by Child (6) are matters that well may be and probably are in part in-

fluenced by external as well as by internal factors, but it is extremely difficult—in fact usually impossible—to separate clearly these influences.

The most certain, and probably the most important, thing we know about senescence is that it cannot be sharply delimited to particular ages or a particular part of the life cycle, but is simply one respect of the *continuous* change of the organism with time, as long as it lives from the very beginning of the life of the individual to the end at death. This was first clearly shown by Minot (18). Every phenomenon of life changes continuously and regularly as the individual exhibiting it continues to live.

C. *Genetic constitution*. This may be either (or both)

a. Specific relative to life duration *per se*, and, in so far as it is operative at all, directly determinative of the particular definite life duration of the individual, or

b. Non-specific relative to life duration *per se* but determinative of the constitution (biological personality) of the individual.

D. The *rate of living*, that is to say the time rate of the activities of the individual, in the most comprehensive sense, to include growth, metabolic activity, reproductive activity, and indeed all other functional performance of the organism. The rate of living concept has been developed in detail by Pearl (24). One aspect of it was emphasized by Rubner (41) many years ago, and supported by ingenious experimental and observational data. The inverse correlation between rate of living and duration of individual life has been demonstrated by a considerable body of recent experimental work on various forms. In this laboratory it has been shown, in a series of papers (7, 8, 13, 23, 24, 27, 28, 38), on the life cycle of seedlings grown under rigorously controlled conditions, that duration of life is nega-

tively correlated with rate of growth. MacArthur and Baillie (17) have shown a similar negative correlation between longevity and general metabolic activity in *Daphnia magna*. That rate of living is a major factor in determining longevity admits of no doubt.

E. *Immediately lethal accidents*, including all major catastrophic environmental stoppages of the individual life.

There would seem to be abundant and cogent evidence that the items enumerated above and called *factors* in natural death are real and pertinent elements in the production and the distribution of mortality. It seems impossible to dispute that they are major factors. Of the five the first four are wholly or primarily *biological* in nature. The fifth is at first glance wholly *environmental* in its nature. But this is not completely so, because biological constitution plays some rôle in determining the incidence of accidents.

It is our hypothesis that there are but two fundamental biological *variables* concerned in death and its time distribution. These are:

a. *Genetic constitution*, and

b. *Activity*, in the broadest biological sense of the term, including not only motor activity, but such phenomena as growth, reproduction, and others as well.

To these is to be added a third fundamental variable, not necessarily or essentially biological in its nature, namely

c. *Environment*.

Thus we have as determinative of the life duration of the individual one variable internal and inherent relative to the organism (a), one variable external to the organism (c), and one (b) that in its quantitative expression is related to and in a sense determined by the interactions of (a) and (c).

In our view the rates of both endogenous and exogenous senescence (factors A and

B) are determined by the interaction of these three variables. An individual may grow physiologically old slowly, and because it has such an extremely sound genetic constitution that it can withstand severe environmental buffeting and a high rate of living. Or, on the other hand, an objectively similar result may be attained by an individual of poor constitution that is fortunate in respect of its environment, and maintains a low rate of living.

One of several profound difficulties in proceeding further in a rigorous rational analysis of the problem of life duration lies in the fact that none of the three fundamental variables involved can, as wholes, be precisely measured or stated in quantitative terms. It is true that *elements* of the environment of a living individual, rather narrowly delimited both spatially and in time, can be measured. The same is true, *mutatis mutandis*, for an individual's activity. We can measure some particular activities during more or less short time. But what is wanted is a measure of the individual's *total* activities of all sorts, over its *whole* life; and also a numerical expression that will serve as a measure of net integrated effectiveness of *all* the environmental forces that have acted upon the individual throughout its life.

If and when we have such measures available there will be a better chance than there is now of reaching a rational theory of life duration. In the meantime it seems to us that the crying need is for more observational data, carefully and critically collected for different species of animals and plants, that will follow through the life history from birth to death of each individual in a cohort of statistically respectable magnitude. From such data sound and biologically meaningful life tables can be constructed. Work of this character, laborious as it is,

is likely to be more fruitful of real knowledge than the construction of any mathematical "law" of mortality, however ingenious. For it appears clear that there is no one universal "law" of mortality.

The data discussed in the present paper are sufficient to show that different species may differ in the age distribution of their dying just as characteristically as they differ in their morphology.

LITERATURE CITED

- (1) ALPATOV, W. W. Experimental studies on the duration of life. XIII. The influence of different feeding during the larval and imaginal stages on the duration of life of the imago of *Drosophila melanogaster*. *Amer. Nat.*, Vol. 64, pp. 37-55, 1930.
- (2) ALPATOV, W. W., and R. PEARL. Experimental studies on the duration of life. XII. Influence of temperature during the larval period and adult life on the duration of the life of the imago of *Drosophila melanogaster*. *Amer. Nat.*, Vol. 63, pp. 37-67, 1929.
- (3) BIDDER, G. P. Growth and death. *Linnean Soc.* 5th February, 1925.
- (4) BIDDER, G. P. The mortality of plaice. *Nature*, Vol. 115, pp. 495-496, 1925.
- (5) BROWNLEE, J. The similarity of age vitality in invertebrates and man, based on Professor Raymond Pearl's data. *Amer. Nat.*, Vol. 58, pp. 558-564, 1924.
- (6) CHILD, C. M. Senescence and Rejuvenescence. *Chicago*, 1915, pp. 481.
- (7) EDWARDS, T. I., R. PEARL, and SOPHIA A. GOULD. The growth and duration of life of *Celosia cristata* seedlings at different temperatures. *Jour. Gen. Physiol.*, Vol. 17, pp. 763-781, 1934.
- (8) EDWARDS, T. I., R. PEARL, and SOPHIA A. GOULD. Influence of temperature and nutrition on the growth and duration of life of *Cucumis melo* seedlings. *Bot. Gaz.*, Vol. 96, pp. 118-135, 1934.
- (9) FEKETE, L. Erdömérnöki táblázatok. *Sopron*, 1916, pp. 56-57. [Quoted from Szabó].
- (10) GARDNER, G., and H. HURST. Life tables for white leghorn chickens in the State of Utah. *Utah Acad. Sci.*, Vol. 10, pp. 149-150, 1933.
- (11) GLOVER, J. W. United States Life Tables 1890, 1901, 1910, and 1901-1910. *Washington* (Bureau of the Census), 1921. Pp. 496, 400.
- (12) GONZALEZ, B. M. Experimental studies on the duration of life. VIII. The influence upon duration of life of certain mutant genes of *Drosophila melanogaster*. *Amer. Nat.*, Vol. 57, pp. 289-328, 1923.
- (13) GOULD, SOPHIA A., R. PEARL, T. I. EDWARDS, and J. R. MINER. On the effects of partial removal of the cotyledons upon the growth and duration of life of canteloup seedlings without exogenous food. *Ann. Bot.*, Vol. 48, pp. 575-599, 1934.
- (14) GREENWOOD, M. "Laws" of mortality from the biological point of view. *Jour. Hyg.*, Vol. 28, pp. 267-294, 1928.
- (15) GRIFFIN, C. E. The Life History of Automobiles. *Michigan Business Studies* (Univ. of Mich.), Vol. I, 1928. Pp. v + 42.
- (16) HASE, A. Über die deutschen Süßwasser-Polypen *Hydra fusca*, etc. *Arch. f. Rassen- u. Gesellschafts-Biologie*, Bd. 6, pp. 721-753, 1909.
- (17) MACARTHUR, J. W., and W. H. T. BAILLIE. Sex differences in mortality and metabolic activity in *Daphnia magna*. *Science*, Vol. 64, pp. 229-230, 1926.
- (18) MINOR, C. S. Age, Growth and Death. *New York*, 1908. Pp. 280.
- (19) NOYES, B. Experimental studies on the life-history of a rotifer reproducing parthenogenetically (*Proales decipiens*). *Jour. Exper. Zool.*, Vol. 35, pp. 225-255, 1922.
- (20) PEARL, R. Experimental studies on the duration of life. VI. A comparison of the laws of mortality in *Drosophila* and in man. *Amer. Nat.*, Vol. 56, pp. 398-405, 1922.
- (21) PEARL, R. The Biology of Death. *Philadelphia* (J. B. Lippincott Co.), 1922.
- (22) PEARL, R. The graphic representation of relative variability. *Science*, Vol. 65, pp. 237-241, 1927.
- (23) PEARL, R. Experiments on longevity. *Quart. Rev. Biol.*, Vol. 3, pp. 391-407, 1928.
- (24) PEARL, R. The Rate of Living. *New York* (Alfred A. Knopf), 1928. Pp. vii + 185.
- (25) PEARL, R. Introduction to Medical Biometry and Statistics. Second Edit. *Philadelphia* (W. B. Saunders Co.) 1930. Pp. 459.
- (26) PEARL, R., and DOBBING, C. R. A comparison of the mortality of certain organisms with that of man. *Science*, Vol. 57, pp. 209-212, 1923.
- (27) PEARL, R., T. I. EDWARDS, and J. R. MINER. The growth of *Cucumis melo* seedlings at different temperatures. *Jour. Gen. Physiol.*, Vol. 17, pp. 687-700, 1934.

- (28) PEARL, R., T I EDWARDS, AGNES A WINBOR, and C P WINBOR Aeration and growth of canteloup seedlings (*Cucumis melo*) *Amer Jour Bot*, Vol 21, pp 242-250, 1904
- (29) PEARL, R., J R MINER, and S L PARKER Experimental studies on duration of life XI Density of population and life duration in *Drosophila* *Amer Nat*, Vol 61, pp 289-318, 1927
- (30) PEARL, R., and S L PARKER Experimental studies on the duration of life I Introductory discussion of the duration of life in *Drosophila* *Amer Nat*, Vol 55, pp 481-509, 1921
- (31) PEARL, R., and S L PARKER Experimental studies on the duration of life II Hereditary differences in duration of life of line-bred strains of *Drosophila* *Amer Nat*, Vol 56, pp 174-187, 1922
- (32) PEARL, R., and S L PARKER Experimental studies on the duration of life III The effect of successive etherizations on the duration of life of *Drosophila* *Amer Nat*, Vol 56, pp 273-280, 1922
- (33) PEARL, R., and S L PARKER Experimental studies on the duration of life IV Data on the influence of density of population on duration of life in *Drosophila* *Amer Nat*, Vol 56, pp 312-322, 1922
- (34) PEARL, R., and S L PARKER Experimental studies on the duration of life V On the influence of certain environmental factors on duration of life in *Drosophila* *Amer Nat*, Vol 56, pp 385-398, 1922
- (35) PEARL, R., and S L PARKER Experimental studies on the duration of life IX New life tables for *Drosophila* *Amer Nat*, Vol 58, pp 71-82, 1924
- (36) PEARL, R., and S L PARKER Experimental studies on the duration of life of *Drosophila melanogaster* in the complete absence of food *Amer Nat*, Vol 58, pp 193-218, 1924
- (37) PEARL, R., S L PARKER, and B M GONZALEZ Experimental studies on the duration of life VII The mendelian inheritance of duration of life in crosses of wild type and quintuple stocks of *Drosophila melanogaster* *Amer Nat*, Vol 57, pp 153-192, 1923
- (38) PEARL, R., FLORENCE B WHITE and J R MINER Age changes in alcohol tolerance in *Drosophila melanogaster* *Proc Nat Acad Sci*, Vol 15, pp 425-429, 1929.
- (39) RAU, P The biology of the roach, *Blatta orientalis* Linn *Trans Acad Sci, St Louis*, Vol 25, pp 57-79, 1924
- (40) RAU, P., and N RAU Longevity in saturniid moths and its relation to the function of reproduction *Trans Acad Sci, St Louis*, Vol 23, pp 1-78, pl I-V, 1914
- (41) RUBNER, M Das Problem der Lebensdauer und seiner Beziehungen zu Wachstum und Ernährung *Munchen und Berlin* 1908, 208 pp
- (42) RUŽIČKA, V Some remarks to the analysis of the determiner of duration of life *Memorial Publ in honor of the 100th Birthday of J G Mendel Prague*, 1925 Pp (of reprint) 1-17 [See also earlier papers by Růžička and his students there referred to]
- (43) STEINFELD, H McD Length of life of *Drosophila melanogaster* under aseptic conditions *Univ of California Publ in Zoology*, Vol 31, No 9, pp 131-178, 1928
- (44) SZABO, I The three types of mortality curve *QUART REV BIOL*, Vol 6, pp 462, 463, 1931
- (45) SZABO, I., and M SZABO Lebensdauer, Wachstum und Altern, studiert bei der Nachtschneckenart *Agriolimax agrestis* L *Biologica Generalis*, Bd 5, pp 95-118, 1929





RESULTS IN THE PHYLOGENY OF A GENUS OF SNAILS

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A PAPER recently published by me (1932) treats of the phylogeny of the European representatives of *Viviparus* or *Paludina*. Under these names is comprehended a widely distributed and notable genus of prosobranch freshwater gastropods (snails). The number of its subgenera is about a dozen. Many of them at present live in Asia. The subgenus *Viviparus s. str.*, however, inhabits every part of the globe, and is the only one in Europe. It occurs in North America chiefly in the Missouri and Mississippi regions and in Cuba, without mentioning that the European species *Viviparus viviparus* in some localities has been imported by man. The other North American genera are *Campeloma* (*Melantbo*), *Lioplax*, and *Tulotoma*, the latter only in Alabama. In South America are to be found only fossils, in Central America neither fossil nor living species have yet been discovered.

In spite of the limitation of my investigations to the European species (fossil and recent), several results, I think, will be of some interest from a more biological point of view.

Chronological and, as one may therefore suppose, phylogenetic seriations of the shells could be made on the basis of the general shapes of the shells, but not so extensively on the basis of the shapes of the apex (or vertex: acute, obtuse, or subacute) nor of the varying thickness of the shells, and not at all on that of the finer sculpture (i.e. principally the vestiges of the spines which occur on young (neonate) shells, and which, when broken

off, leave either very small tubercles, or pits, upon a greater or smaller number of the whorls).

THE GENEALOGY OF THE GENUS VIVIPARUS

The phylogenetic seriation, which surely does not represent lines from ancestors to descendants, begins with *Viv. beaumontianus* in upper freshwater Cretaceous deposits of the South of France—since it is not certain that the older "*Viviparus*" of the literature really belong to the genus. The species *beaumontianus* still resembles the marine Turbinids, especially in the relatively clear cone-shape of nearly equal height and breadth (compare Fig. 1 with Fig. 2). From a form like this diverge: a "broad" series, in which the shells remain relatively broad, whilst the whorls become more inflated and the suture deeper, ending in the living species *Viv. viviparus*, which is widely distributed in Europe; and a "slender" series, whose representatives are more slender, retain more the flattened whorls, and already early resemble in some degree the recent species *Viv. pyramidalis*, in Northern Italy. From the slender series there descend: slender forms, whose whorls, however, become more inflated, leading to the recent species *Viv. fasciatus*; and the famous branching genealogical tree of the Pliocene Slavonian Paludines, consisting in direct lines of descendants.

The female genital apparatus of the three recent species named presents some differences, which, however, seem to correspond more to the different specific rate of propagation than to any phylogenetic

relation, the rate of propagation being greater, and the dimensions of the neonates smaller, in small and rapid streams than in larger bodies of water.

The numbers of chromosomes (*viv.* 7, *pyr.* 9, and *fasc.* 10 double-chromosomes in the stages of chromosome-conjugation)



FIG. 1. *TURBO RUGOSUS* MEDITERRANEAN, RECENT. REPRESENTATIVE OF THE TURBINIDAE ONE-HALF NATURAL SIZE



FIG. 2. *VIVIPARUS BEAUMONTIANUS*. UPPER CRETACEOUS DEPOSITS, ETAGE DE ROGNAC, SOUTHERN FRANCE NATURAL SIZE



FIG. 3. *VIVIPARUS VIVIPARUS* VAR. *AMPULLACEUS* UPPER PLIOCENE OF THE VAL D'ARNO ITALY NATURAL SIZE

would be in accord with the above phylogenetic seriation. In general, though with much variation from the trend, the inclination of the aperture (i.e. the mouth of the shell) in the phylogenetic evolution diminishes (compare Fig. 1 with Fig. 3). The primitive obliquity of the aperture of the marine Turbinids (Fig. 1), Trochids,

Pleurotomariids and some fossil freshwater Viviparids (not even maximal in *beaumontianus*) is the same that results from rolling up a plastic cone to the shape of a snail-shell; it produces, in the animal creeping horizontally, a steep attitude of the shell. The "steep" aperture (Fig. 3), which in the creeping animal is more inclined to the horizontal, allows a shell to be turned more backwards (resulting in a horizontal situation of the spindle in highly evolved marine representatives of neighboring groups, e.g. *Conus*, *Murex*); in some fossils it is attained by the edge of the aperture being "drawn forward" (Fig. 3), which in recent forms is mostly equalized, the edge being plane again.

THE GENEALOGY OF THE PLIOCENE SLAVONIC VIVIPARUS

The genealogical tree of the Pliocene Slavonic *Viviparus* (*Paludina*) shown in Fig. 4 is considerably simpler than the classic sketch of Neumayr (1875), from which it differs especially in beginning with *leiostracus* (which already greatly resembles the recent *pyramidalis*, in the same way *grandis*, seen in Fig. 4, the Transylvanian fossil form, is a giant form of *leiostracus*, closely corresponding to the living Mantuan giant form ("mantovana") of *pyramidalis*), instead of *neumayri*. The latter is regarded as an already more inflated variant in the direction of *fasciatus* (in the same deposits, whilst the steps above *pannonicus* are stratigraphic and consequently chronologic). A great simplification is effected by the omission of some doubtful species and by uniting two (*dezmanianus* and *nothus*, the latter regarded as merely a modification caused perhaps by wave action). My arrangement differs also from Neumayr's in the separate derivation of some broader forms (not included in Fig. 4) from the above "broad" series and in the separation of

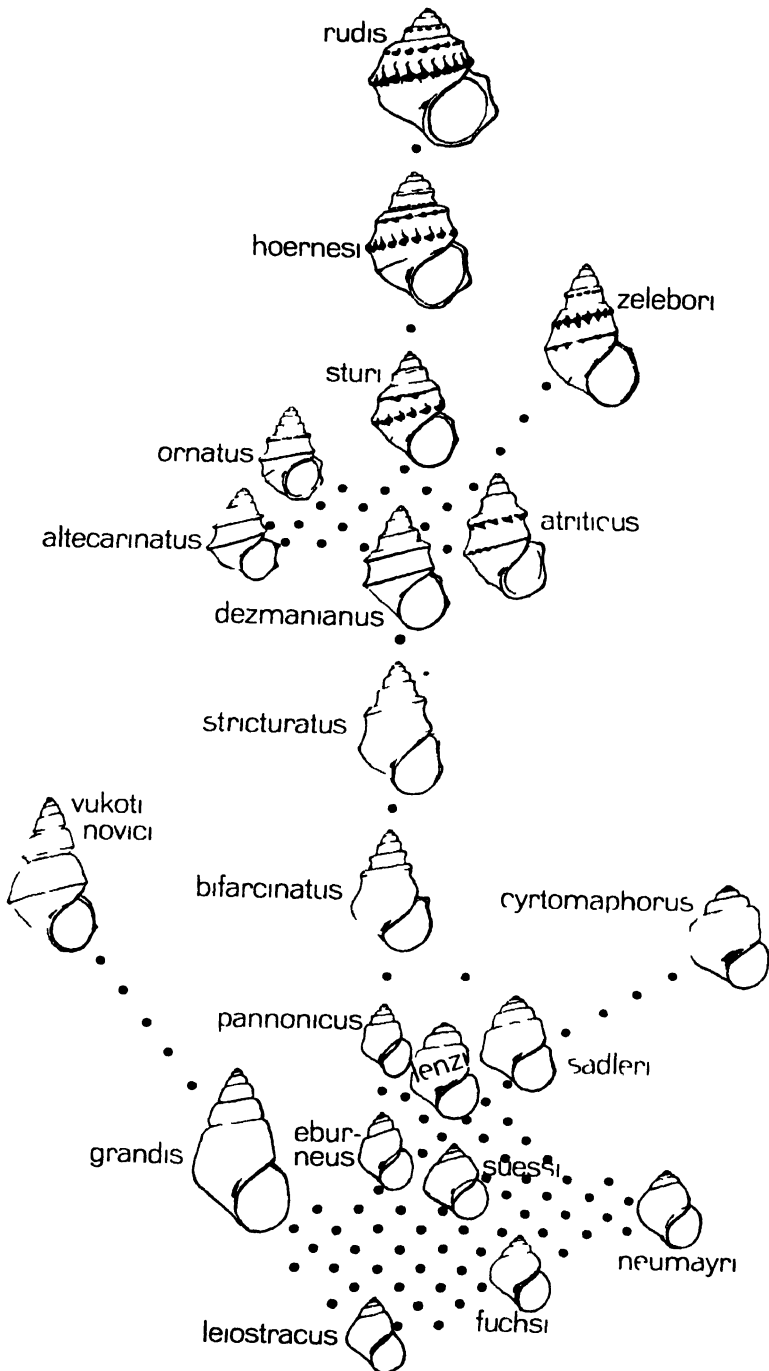


FIG. 4. GENEALOGICAL TREE OF THE PLIOCENE SLAVONIAN PALUDINES (*VIVIPARUS*)

the forms of the island Kos (apex very acute). The Slavonian snails clearly show the increasing "Tulotomoidy" (i.e., angularity and nodosity, convergence to the North American recent subgenus *Tulotoma* [in Alabama] of the genus *Viviparus*), increasing thickness of the shell, and embryonic similarity in the sense of K. E. v. Baer (or, in my terminology (1927), ontogenetically increasing deviation). The latter is not so broad as the less exact "biogenetic law" or "biogenetic rule"; the young of the descendant species resemble those of the ancestral species, especially in early stages of development. In the step *dezmanianus* → *sturi*, however, the new character, nodosity, appears already in the young; often it vanishes later, sometimes it persists; as a result of which there is a sudden appearance of the character in the series of the adults.

STATISTICAL METHODS

In order to characterize as objectively and distinctly as possible the various species or collections, the height (H), breadth (B) and weight (g) of each individual were determined. The first aim of these measurements is to give exact information upon the material instead of the too customary, merely subjective characterisations as "broad," "slender," "shell thick," etc., or instead of the determination merely of the range. For every form, for individuals of more than 10 mm. height, a linear equation between H and B has been fitted, for instance: *beaumontianus*, $B = 0.78 H + 2.6$ mm.; *viviparus*, $B = 0.63 H + 5.4$ mm., *pyramidalis*, $B = 0.55 H + 5.2$ mm. Phylogenetically, on the whole the coefficient of H diminishes, and the constant term increases; in other words, the shell passes more and more from the cone-shape to the "tun"-shape (upper half of a tun), in which the older individuals are more slender in proportion to

height than the younger. Ten individuals are a very good sample, from which an equation of high reliability for the respective locality can be calculated. What still needs correction, is not so much the fact that the complete curve, including the young of less than 10 mm. height, is probably a parabola, but the lack of a formula for the probable error of the equation; in practice, however, this is seldom employed by me and is not of great importance for my conclusions.

The simple calculation for finding this linear equation between B and H is as follows: n being the number of individuals at hand, we take the mean height H_1 and the mean breadth B_1 of the $\frac{n}{2}$ smallest individuals and similarly the mean height H_2 and the mean breadth B_2 of the $\frac{n}{2}$ largest.

Then

$$H_2 \frac{B_2 - B_1}{H_2 - H_1} = z; B_2 - z = y; \frac{B_2 - B_1}{H_2 - H_1} = x;$$

and

$$B = x \cdot H + y.$$

Several "forms," until now described under separate names and partly used for the construction of phylogenetical hypotheses, could convincingly be demonstrated by this calculation to be nothing more than the rare extremes of variation in breadth especially on the slender side, in consequence of old age, sometimes in connection with slow growth. The details of this, however, are of special interest only for the European zoologist. Furthermore, for each individual the weight-index $S = g \cdot 10^4 / (H \cdot B^3)$ is found and thence, with caution, the mean weight-index, both for the species as a whole and for the smaller (younger) and the larger individuals. Then, taking account of

the position and the number of winterings, in the recent species the local forms, mostly phaenotypic (somatic), are analyzed, for instance: a large form which, in growing, remains broad, has grown rapidly in youth; a slender giant form has grown slowly in youth; a stunted form is already slender in proportion to height (demonstrated by the measurements: slenderness of age). Such differences in average slenderness or breadth are scarcely recognizable by the eye, except by a very practiced one; and it is impossible to deal with them, except by measurement.

HYBRIDIZATION

Other chapters treat of hybrid populations after the demonstration of one such living in the southern part of the Lake of Garda as hybrids between the two species *pyramidalis* (shell thin, with bands) and *ater* (shell thick, black, perhaps a relatively new mutation from *pyramidalis*, also with nine double-chromosomes); in the hybrid population the shells are with bands, or black, or intermediate; the thickness and color of the shells varying independently. In the females with bands, the embryos are all with bands; in the intermediate and still more in the black females, black embryos appear by the side of those with bands (consequently bands are recessive, black dominant). All other hybrid populations of *Viviparus* treated of by me hitherto being merely hypothetical, I do not wish to deal further with this aspect of the European fauna. Under ideal conditions—i.e. when both parent species are mixed in equal number with each other, and when the environment of the hybrid population produces no somatic modification (as in the case in the southern part of the Lake of Garda)—we must expect the equation and the average weight-index of the hybrid population to be midway between the two parents, and

the variation (or the probable individual deviation) of $H:B$ in each H -group and of S to be greater than in the parents. The best numerical evidence of this was found in a form hitherto much discussed, *spurius* among the Pliocene Slavonians, by regarding it as a hybrid between *sadleri* and *bifarcinatus*.

All I have mentioned here, of course, are only the briefest hints. Now, as may be seen, the above investigations follow many lines, in part new. Owing to this, it is not easy to bring all of the results in relation to other similar works.

As to the morphometry, no similar attempt has been made before; and I can scarcely hope soon to find many successors. Indeed, I have worked four years upon my material, of which time a considerable part was devoted to the elaboration of methods of measurement and calculation. But a successor can use it in shorter time and will necessarily be led to it when he endeavors to deal with as many measurements as are sufficient in the descriptive sense for characterizing the dimensions of both younger and older individuals. But the morphometry as detailed above, of course, cannot be used with shells of a more complicated mode of growth, for example the laced, spindle-shaped shells of *Clausilia*, or of *Fusus* among the marine forms, in which the relation between H and B is by no means linear.

WORK OF OTHER AUTHORS

Concerning mutation and heredity, I only wish to say that recently (Schlesch, 1930) in the species *Viviparus fasciatus* there have also been found—only occasionally, it is true—individuals with dark color, highly comparable in this respect to *ater*, the variant of *pyramidalis*, probably caused by an external factor yet unknown, and certainly of the same he-

redity as in the Italian form. Concerning hybridization between different species, other investigations of myself (1929) and of my student Möller (1932) bring clearness also into the middle European forms of the *Anodonta*-mussels, a much discussed problem for about 50 years (Clessin, 1884), which is now illuminated by indubitably proving that there exist not one (as Clessin thought) but two species, *cygnea* and *piscinalis*, which in some localities live together without interbreeding, whilst in others they seem to form hybrids, to judge from the intergrading characters of many individuals between the two species.

The above work on *Viviparus* being regarded in the first place as a phylogenetical one, the question arises, what similar works here afforded similar results. The classical investigations of Neumayr (1875), which are often regarded as a most convincing test of phylogenetical evolution, and in this respect compared to Reichenow's elucidation of the Tertiary Steinheimian *Planorbis*, were already mentioned above. From Gottschick (1919) and Plate (1919) we know that in the latter (the planorbs) the chronological changes are only somatic, the water of higher temperature rendering the shells more and more conical, but that the change was always reversible, when the hot springs cooled. To my mind, the variations in the Slavonian *Viviparus* are to a great extent genotypic, since hybridization between different types is probable. Even now, however, we do not know the cause of this great mutability: was it the increasing salinity of the water (Forbes, 1847), was it the effect of waves, or did the water become more and more brackish and fresh, as supposed by Neumayr? Thus, many questions still remain open, but, in contrast with Dacqué, who regarded the whole genealogical tree of the

Slavonian *Viviparus* as merely a construction upon paper, we could convincingly demonstrate its reality, except for some points of which Neumayr himself, even more exactly than generally is known, emphasized the doubtfulness.

As to other works upon land and freshwater molluscs, we must confess that they give as yet very little phylogenetical information upon most of the families, and that most questions are still at sixes and sevens. Nobody can positively say whether the Palaeozoic Anthracosiidæ-mussels or the American Carboniferous *Palaeorbis*, *Archaeozonites*, *Dendropupa*, etc., are ancestors of the Mesozoic and Caenozoic *Unio*, *Planorbis*, *Zonites*, *Pupa*. The giant work of Sandberger (1870-1875) notes, as it seems to me, in the Jurassic period the first indubitable representatives of genera of today. Following his chronological account, we see clearly the forms becoming more like the recent ones, the younger they are in the history of the earth's surface, but each form in its locality and time appeared we know not from where, and it is impossible to draw phylogenetical lines even approximately from one to another. Moreover, the author ascribes so many European fossil forms as nearest relations to an American or Asiatic living species; in other words, he saw the phylogenetic and geographic connections highly complicated; certainly, however, this is very speculative, for in *Viviparus* we could not follow him and often saw him overlook the much nearer intraeuropean relations.

Only in the genus *Pupa* and the family of Pupidae have we a paper of O. Boettger devoted to a task similar to mine, describing and connecting a group of snails, definitely terrestrial, and narrowly circumscribed in space and time. The genus *Pupa* has existed, according to the author, since the Pliocene in the species *Pupa*

muscorum, since the Pleistocene in other species, and the most of the Oligocene species, driven southward by the Tertiary sea or by the glacial period, have their nearest living allies in Oceania, the West Indies and upon Atlantic islands. Whether the latter conclusions are right, must be decided in future.

In the Viviparids of the world, a great work of Prashad (1928) which appeared shortly before mine, seeks many phylogenetic connections, but none between different parts of the globe, except, hypothetically enough, for Cretaceous or earlier times, in which these snails came up from the sea into the rivers or lived at first a short time in the latter. The author assumes landbridges between the different continents, a hypothesis scarcely very acceptable to-day. In detail, many of his results are very evident, e.g. that the

Viviparids with ridges and nodes, the "Tulotomoids" in my expression, in the different continents, as Asia, Europe (here the Pliocene Slavonians), North America (the *Tulotoma's* in Alabama), are only convergent (cf. Annandale, 1924). The European forms being somewhat briefly treated in the work of Prashad, I found still unsolved the problems, to answer which was the first purpose of my investigation.

We could enumerate only a small number of works on material similar to mine. Surely, the restriction and, nevertheless, completeness in the material is the sole way leading to results free from contradiction, and I believe that in the future each investigator of such material will tend to treat it from newer points of view and by means of exact methods, which was my aim.

LIST OF LITERATURE

- ANNANDALE, N. The evolution of the shell sculptures in fresh water snails of the family Viviparidae. *Proc. R. Soc. London* (B), 96, 1924.
- BOETTGER, O. Die Entwicklung der Pupa-Arten des Mittelrheingebiets in Zeit und Raum. *Jahrbuch. d. Nassau. Vereins f. Naturk.*, Jahrg. 42, 1889.
- CLESSIN, S. Deutsche Exkursions-Molluskenfauna. 2. Aufl. *Nürnberg*, 1884.
- DACQUÉ, EDO. Vergleichende biologische Formenkunde. *Berlin*, 1921.
- FORBES, 1847, cited in Abel, O., Paläobiologie und Stammesgeschichte. *Jena*, 1929.
- FRANZ, V. Ontogenie und Phylogenie. Das sogenannte biogenetische Grundgesetz und die biometabolischen Modi. *Berlin*, Springer, 1927. (Spemann-Vogt-Romeis, Abhandlungen z. Theor. d. org. Entw., 3, 1927.)
- FRANZ, V. Zur Artenfrage der Anodonten. *Arch. Molluskenk.*, 61, 1929.
- FRANZ, V. *Viviparus*. Morphometrie, Phylogenie und Geographie der europäischen, fossilen und rezenten Paludinen. *Denkschr. d. mediz.-natw. Gesellschaft zu Jena*, 18, 1 Lieferung, 1932.
- GOTTSCHEK, F. Die Umbildung der Süßwasserschnecken des Tertiärbeckens von Steinheim a. A. unter dem Einflusse heisser Quellen. *Jen. Ztschr.*, 56, 1919/20.
- MÖLLER, H. Artunterschiede der deutschen Anodonten. *Jen. Ztschr.*, 66, 1932. (I.-Diss. rer. nat. Jena 1932.)
- NEUMAYR, M., and PAUL, C. M. Die Congerien- und Paludinenschichten Slavoniens und deren Fauna. *Abb. k. k. geol. Reichsanstalt*, 7, Wien, 1875.
- PLATE, L. Bemerkungen über die deszendenztheoretische Bewertung der Umwandlungen von *Planorbis multiformis*. *Jen. Ztschr.*, 56, 1919/20.
- PRASHAD, B. Recent and fossil Viviparidae. A study in distribution, evolution and palaeogeography. *Memoirs Indian Mus.*, 3, No. 4, Calcutta, 1928.
- SANDBERGER, C. F. R. Die Land- und Süßwasser-Conchylien der Vorwelt. *Wiesbaden*, 1870-75.
- SCHLESCH. Kleine Mitteilungen. *Arch. Molluskenk.*, 62, 1930.



NEW BIOLOGICAL BOOKS

The aim of this department is to give the reader brief indications of the character, the content, and the value of new books in the various fields of biology. In addition there will frequently appear one longer critical review of a book of special significance. Authors and publishers of biological books should bear in mind that THE QUARTERLY REVIEW OF BIOLOGY can notice in this department only such books as come to the office of the editor. The absence of a book, therefore, from the following and subsequent lists only means that we have not received it. All material for notice in this department should be addressed to Dr. Raymond Pearl, Editor of THE QUARTERLY REVIEW OF BIOLOGY, 1901 East Madison Street, Baltimore, Maryland, U. S. A.

BRIEF NOTICES

EVOLUTION

BEFORE THE DAWN.

By John Taine. *The Williams & Wilkins Co., Baltimore.* \$2.00. 8 x 5½; vii + 247; 1934.

John Taine is the pseudonym of E. T. Bell, Professor of Mathematics in the California Institute of Technology and author of *The Queen of the Sciences* and *Numerology*, which have been reviewed in our columns. In this very readable romance he develops the idea that light leaves permanent traces on the objects on which it falls, so that a suitable television apparatus might reproduce the events of past ages. The pageant of evolution which he presents is much more graphic than that to be found in textbooks of paleontology. However, his dinosaurs struck us as disconcertingly anthropomorphic.



GÉNÉTIQUE ET ÉVOLUTION. *Analyse de quelques études mathématiques sur la sélection naturelle. Actualités Scientifiques et Industrielles*, 158. *Exposés de Biométrie et de Statistique Biologique*, III.

By Ph. L'Héritier. *Hermann et Cie, Paris.* 14 francs. 10 x 6½; 43; 1934 (paper).

This is a brief but clear analysis of the work of R. A. Fisher and Sewall Wright giving a schema of a mechanism of evolution founded on mutation and selection.

GENETICS

WORKING DOGS. *An Attempt to Produce a Strain of German Shepherds which Combines Working Ability and Beauty of Conformation.*

By Elliott Humphrey and Lucien Warner. *Johns Hopkins Press, Baltimore.* \$3.50. 9 x 5½; xiv + 253; 1934.

In 1924 Mrs. Harrison Eustis began breeding and training German shepherd dogs for police and military work and as guides for the blind. This very interesting book describes the breeding methods used to produce dogs of superior intelligence, disposition and physique for the different functions for which they are to be trained. Of the temperamental qualities the most important is sensitivity. An oversensitive dog is practically valueless as a worker, while an undersensitive dog is more difficult to train than one of medium sensitivity. Intelligence is highly correlated with success in working. Several traits such as olfactory acuity and distrust, are advantageous in certain forms of work but not in others. Thus distrust is desirable for a liaison dog but detrimental in most other types. Dogs with well developed chests and flanks were found to be more resistant to disease than those with poor development. Sensitivity seems to be inherited in Mendelian fashion but the mode of inheritance of most other traits has not yet been worked out. That the breeding program has been successful, however, is shown by the fact that the rating of the

dogs for most of the desired qualities has shown an upward trend and that, while during the first two years only 16 per cent of the dogs produced completed the courses of instruction and went into service, during the last two years the proportion has increased to 94 per cent. We may, with Pearl in his foreword, look forward to the day when dogs will be bred "capable of performing tasks which have not yet even been thought of as coming within the range of possibilities."



PLANT CHIMAERAS AND GRAFT HYBRIDS.

By W. Neilson Jones. Methuen and Co., London. 3s. 6d. net. 6 $\frac{1}{2}$ x 4 $\frac{1}{2}$; viii + 136; 1934.

Biologists will welcome this account of plant chimaeras, plants "built up of two or more genetically different components arranged in a pattern more or less stable during the life of the individual." Although the problem of their natural origin is still unsolved they can be produced by saddle grafting the scion of one species, *Solanum lycopersicum*, for instance, on the stock of another species, e.g. *S. nigrum*, and subsequently cutting the scion off just above the union. From the layer of callus tissue that forms, adventitious buds develop; sometimes the core of such a bud will be derived from one species and the skin from another. The shoot developing from such a bud has properties intermediate between those of the species involved, and since the relative amounts of tissue in the bud derived from the two species may vary the structure of the shoot is variable also. Many chimaeras are of horticultural importance and numerous workers have studied them on that account. There is another group of workers who have regarded chimaeras as a fruitful field for the study of experimental morphology and they have obtained important results. Professor Jones has prepared a well-organized and well-written account of the literature on the subject, and has provided it with an index and a bibliography.



A BIBLIOGRAPHY OF PLANT GENETICS. U. S. Department of Agriculture Miscellaneous Publication No. 164.

By Marjorie F. Warner, Martha A. Sherman, and Esther M. Colvin. U. S. Government Printing Office, Washington. 50 cents. 9 $\frac{1}{2}$ x 5 $\frac{7}{8}$; 552; 1934 (paper).



GENERAL BIOLOGY

JAMES JOHNSTONE MEMORIAL VOLUME.

By twenty-three contributors. University Press of Liverpool. 21 shillings net. 9 $\frac{1}{2}$ x 6; x + 348; 1934.

The greater proportion of the papers in this volume deal with the geophysical or the biochemical aspects of oceanography. F. J. Cole contributes a biography of James Johnstone, who occupied the Chair of Oceanography at Liverpool at the time of his death in 1932, and E. S. Russell has a synopsis of Johnstone's "The Essentials of Biology." There is a paper on the life history of the Asteroid genus *Luidia*, a review of work on the color changes of fish, a study of the movements of herring as deduced from the catches in weirs set on all sides of a large bay, a bionomical study on *Cardium edule*, two papers on helminthology, a report on the fauna of an artificial pond by the seashore, and a comparison of the seasonal fluctuation of the plankton in the region of Australia and in the Irish Sea. A. C. Redfield has an article on the organic derivatives in sea water, there is a note on the possible presence of enzymes in sea water, and there are longer papers on the distribution of oxygen and salt content in relation to tracing the movements of large masses of water by T. G. Thompson *et al.* and by Gerhard Schott. Wüst has a paper on bottom temperature, Helland-Hansen reports detailed oceanographic observations on the North Sea and the Norwegian Sea, and Jacobsen and Thomsen report a similar study of the Straits of Gibraltar. There are three papers dealing with tides, a statistical paper on curve fitting, and a physical paper in Italian on the penetration of light into water. Three papers are in German, one is in French. Bibliographies are appended to each paper.



SCOLT HEAD ISLAND. *The Story of its Origin: the Plant and Animal Life of the Dunes and Marshes.*

Edited by J. A. Steers. W. Heffer and Sons, Cambridge. 15 shillings net. 8½ x 5½; xvi + 234 + folding map; 1934.

Scolt Head is a low-lying island about four miles in length off the east coast of England in the county Norfolk, a large part of its area lying in the inter-tidal zone. It is still undergoing rapid physiographic change, the formation of dunes and shingle beaches and the filling of marshes go on simultaneously with severe wave erosion in other places. The Cambridge Geography School has established a laboratory there and has been making a careful and varied study of the island and its flora and fauna. Mr. Steers contributes a long section, profusely illustrated with old and new maps and with photographs, on the physiography of the island; V. J. Chapman has a long and excellent chapter on plant ecology, and Miss E. L. Turner has an interesting chapter on the birds that breed on the island. There are shorter papers on pollen analysis of peat, and on the ecology of mammals, invertebrates, bryophytes, and lichens. This represents first-class ecological research in all the departments of a well-rounded cooperative research project and except for the lack of an index there is no fault to find with the presentation of the results.



TRANSACTIONS OF THE BOSE RESEARCH INSTITUTE, CALCUTTA. *Vol. VIII, 1932-1933. Biological and Physical Researches.*

Edited by Sir Jagadis Chunder Bose. Longmans, Green and Co., New York and London.

\$8.40 (U. S. A.); 21 shillings net (Great Britain). 8½ x 5½; vi + 266; 1934.

According to Western habits of scientific thought, to which Sir Jagadis Chunder Bose does not cater, the best paper in this volume is P. C. Basu's anthropometric study of 250 Munda men, a tribe of uncertain phylogenetic affinities living in the highlands of Central India. Except for stature, which averaged 1581 mm., all of his 15 measurements were made on the head or face. The usual indices and measures of variation are presented; for example, the cephalic index is 74 and the nasal index 83. There is a good, but brief, discussion of the non-quantitative characteristics usually studied by physical anthropologists, and an intensive crani-

ometric study involving 64 measured characteristics and 31 indices made on 7 Munda skulls. Both sets of measurements were made with standard anthropometric technique. Also of possible interest to Occidental scientists are papers of the seasonal variation in manganese content of the leaves of conifers, on the chemical constitution and properties of substances isolated from Indian plants, and two papers on physics. These papers are provided with bibliographies and are presented in the conventional way.

In striking contrast, however, are seven papers by Bose and his associates of the type he has been publishing for about 30 years which involve elaborate automatic recording devices to magnify movement or elongation of plant organs, fish gills, or visceral organs, and to register their movements on smoked plates. Somehow the discussion is never very profound. There are no bibliographies, no indication as to the relation of the findings to the work of other people, no tables of data, and no definite information about variation or repetitions. There is no index.



L'ANALYSE MITOGÉNÉTIQUE SPECTRALE. *Actualités Scientifiques et Industrielles, 150. Exposés de Physiologie, IV.*

By A. and L. Gurwitsch. Hermann et Cie, Paris. 12 francs. 10 x 6½; 39; 1934 (paper).

Probably what most biologists want to know about this booklet is, what figures does Gurwitsch give for the intensity of mitogenetic radiation, and how do these figures compare with the sensitivity of the Geiger-Müller counter, the only physical means of detecting this radiation.

"An approximate calculation gives us the following values: we shall take as point of departure the intensity of 1000 quanta per second per square centimeter—according to the data of Rajewsky, Frank and Rodionoff."

The two most recent attempts (not noted in this brochure) to detect mitogenetic radiation, that of Gray and Ouellet with a counter sensitive to 50 quanta per second per square centimeter and that of Lorenz with a counter sensitive to 10-15 quanta per second per square centimeter, ended in failure; and in both cases the mistakes

made by previous workers, some of whom have found positive effects, were identified and avoided.

Gurwitsch discusses briefly the mitogenetic spectra emitted by solutions in which biochemically important reactions were taking place, the spectra being constructed from the growth responses of yeast exposed in a quartz spectroscop. This booklet is far below the high standards of the other numbers of the *Actualités Scientifiques*.



DYNAMIC BIOLOGY.

By Arthur O. Baker, Lewis H. Mills.
Edited by William L. Connor. Drawings by Earl Wolf. Rand McNally and Co., New York. \$1.72. 7½ x 5½; x + 722; 1933.

The apparent tendency in high school biology texts seems aimed to make it unnecessary for the teacher to use any initiative whatever. The idea may be good for classes inflicted with poor teachers but it does seem too bad to penalize the good teachers to quite the extent that such dramatizations of subject matter must. Far be it from us to advocate dry-as-dust texts—although to a biologist it does not seem as though any book could make general biology dull—but there is surely a limit to the jazzing up that is desirable.

There are many excellent features to this particular book. The amount of emphasis on ecology and the chapters on genetics and paleontology are especially good, although the genetics chapter seems rather detailed and complicated for high school students. The diagrams and drawings are excellent, but many of the photographs are poorly reproduced. One particularly good feature is the indication of pronunciation given for all technical terms. There is a classification table for both plants and animals and a glossary and index.



BIOLOGIE DER FORTPFLANZUNG IM TIERREICH. *Verständliche Wissenschaft XXII.*

By Ulrich Gerhardt. Julius Springer, Berlin. 4.80 marks. 7½ x 4½; viii + 149; 1934.

The present book on the biology of reproduction is the twenty-second of a popular

science series. The present volume is designed to make the vast field of animal reproduction intelligible to those who are not specialists in the field. The book does not consider reproduction according to the systematic classification of animals, but discusses various phases of the morphology and development of sexual organs in general terms with examples taken from specific animals. There is only a very small amount of space devoted to asexual reproduction.



VITALITY.

By Boris Sokoloff. E. P. Dutton and Co., New York. \$2.00. 7½ x 5½; 181; 1934.

The first part of this book is concerned with the vitality of man and animals, believed by the author to reside in the cortex of the suprarenal, "the gland of life." The hormone of this gland is also dramatically called "the hormone of vitality." The second part develops the thesis that vitality has as its most particular main source lactic acid. In fact the author becomes so eloquent over the merits of lactic acid as fuel for the brain, general internal antiseptic, and stimulator of vitality that the reader begins to wonder if all depressions and feelings of malaise could not be cured by a squirt of lactic acid. The third part is called "The crisis of vitality—cancer." There is an interesting chapter on Napoleon's case. The book suffers from its attempt to popularize too recent research in problems of vitality and cancer. When there is more definitive knowledge concerning these problems, and conclusions have been more thoroughly and widely established, then such a book for lay consumption would have more value.



ELEMENTS OF MODERN BIOLOGY.

By C. R. Plunkett. Henry Holt and Co., New York. \$3.00. 8½ x 5½; viii + 540; 1934.

This is a text somewhat simpler but along the same general lines as the author's *Outlines of Modern Biology*, already noticed here (Volume 5, p. 364). Some of the more

difficult sections of the earlier text involving a student's knowledge of chemistry and physics have been omitted, while other parts have been expanded and further clarified. What has already been said about *Outlines of Modern Biology* applies to this book.



BIOLOGY FOR SCHOOLS. *A Textbook Suitable for School Certificate and Similar Examinations. Second Edition.*

By E. R. and A. V. Spratt. University Tutorial Press, Cambridge. 4s. 6d. $7\frac{1}{2} \times 4\frac{1}{2}$; viii + 407; 1934.

An excellent, well-written textbook of Biology for beginners of high school age. The authors are not afraid of using big words, and there is no sugar coating as is so often the case in such books designed for the pre-college student. In fact any student started in on this book would probably be better acquainted with the fundamentals of biology than most are after a first year college course.



VIE ET SURVIE.

By Edgard-Emmanuel Bonnet. Messageries Hachette, Paris. 20 francs. $9 \times 5\frac{1}{2}$; 489; 1934 (paper).

Idealistic speculations on the origin of physical and spiritual life and its transmission. It lacks the fervor and dialectics of many works of its type but the author has some knowledge of scientific facts which he uses very adroitly for his metaphysical interpretations.



HANDBUCH DER BIOLOGISCHEN ARBEITSMETHODEN. *Lieferung 429. Polarisations-optische Analyse des submikroskopischen Baues von Zellen und Geweben.*

By W. J. Schmidt. Urban und Schwarzenberg, Berlin. 13.50 marks. 10×7 ; 231; 1934 (paper).

This number of the Abderhalden *Handbuch* series outlines the theory and technique of polarization analysis of the sub-microscopic structure of plant and animal cells and tissues, with directions for pre-

paring the various materials to be analyzed.



BERMUDA OCEANOGRAPHIC EXPEDITIONS 1929-1930. *Zoologica, Vol. 13, Nos. 1 and 2.* By William Beebe. New York Zoological Society, New York. 75 cents net. $9\frac{1}{2} \times 6\frac{1}{2}$; 36; 1931 (paper).

BERMUDA OCEANOGRAPHIC EXPEDITIONS 1931. *Zoologica, Vol. 13, No. 3.*

By William Beebe. New York Zoological Society, New York. 25 cents net. $9\frac{1}{2} \times 6\frac{1}{2}$; 9; 1932 (paper).

A brief account of the establishment and present method of carrying out routine work in the Bermuda Oceanographic station, supplemented by a list of individual nets hauled in for 1929, 1930 and 1931, with accompanying data.



BIOLOGY. *Elementary Science Series.*

By E. R. and A. V. Spratt. University Tutorial Press, Cambridge. 1s. 9d. $7\frac{1}{2} \times 4\frac{1}{2}$; viii + 140; 1934.

Designed for school children, and on the whole better than most such books, as it is more accurate and thorough.



BULLETIN DE L'ASSOCIATION DES DIPLÔMÉS DE MICROBIOLOGIE DE LA FACULTÉ DE PHARMACIE DE NANCY, No. 8.

$9\frac{1}{2} \times 6\frac{1}{2}$; 36; 1934 (paper).



HUMAN BIOLOGY

REVELATIONS OF A PRISON DOCTOR.

By Louis Berg. Minton, Balch and Co., New York. \$2.50. $8\frac{1}{2} \times 5\frac{3}{8}$; vii + 255; 1934.

The psychopathology of prison inmates, the horrid ravages made by their drug addictions, their homosexuality, their venereal diseases, their "rackets" and riots, all set forth in great detail in this book by Dr. Berg, who has been Senior Medical Officer on Welfare Island, make depressing reading. But the author is hopeful.

Most offenders can and must be reclaimed. To accomplish this we must reorganize our legal system. Equality before the law for rich and poor, quick trials for all and uniformity of sentence for similar offenses, are imperative. It is the knowledge that there is no immunity from arrest, no possibility of police or judicial corruption, and that impartial justice will follow apprehension, that accounts for the difference between our enormous crime rate and England's modest one.

No court in the land should be without its psychiatric adviser; no sentence should be pronounced without the aid of individual recommendation from a competent medical examiner as to its length and nature, based upon study of the offender. In the last analysis, such a procedure would be able to secure adjustment in every instance through supervised probation, whereas all hope would be lost once the individual were confined even in the most ideal prison.



THE ANDAMAN ISLANDERS.

By A. R. Radcliffe-Brown. *The Macmillan Co., New York; University Press, Cambridge.* \$10.00. 8 $\frac{3}{4}$ x 5 $\frac{1}{2}$; xiv + 510 + 19 plates and 2 maps; 1933.

Professor Radcliffe-Brown spent the years 1906 to 1908 in the Andaman Islands collecting the material upon which this book is based. It is much more complete and thorough, and naturally more modern in its methodology, than the study of the same people by Man (cf. QUARTERLY REVIEW OF BIOLOGY, Vol. 8, p. 113) a quarter of a century earlier. But it is interesting and valuable to have the two independent accounts for comparison. The material is presented under four heads: social organization, ceremonial customs, religious and magical beliefs, and myths and legends. Then follow two long chapters giving the author's interpretation of the "meaning" and "function" of Andamanese customs, beliefs, ceremonies, myths and legends. Methodologically these chapters are the book's most important contribution. Appendices deal with the technical culture and language. The book is well illustrated and indexed.



THE METHOD AND THEORY OF ETHNOLOGY. *An Essay in Criticism.*

By Paul Radin. *McGraw-Hill Book Co., New York.* \$2.50. 7 $\frac{3}{8}$ x 5; xv + 278; 1934.

This vigorously written book will be extremely useful to beginning students of

anthropology and human biology and will entertain older hands. This usefulness will be in no serious way impaired by the fact that the author is an advocate of one particular view as to the philosophy of ethnological methodology, for he plays fair in his exposition of the views he opposes. Ethnology is the study of aboriginal cultures. Anthropologists divide into three camps in their attitudes toward primitive cultures, and these attitudes reflect themselves in methodology, according to Radin. One attitude conceives the purpose of ethnology to be to trace the evolution of culture; another to demonstrate the diversity of cultures; the third, merely to describe objectively with no purpose other than description. Radin is a forthright but good-tempered critic. We think he does his case for the purely objective descriptive attitude much harm by his insistence (unnecessary and not altogether well-informed as it seems to us) that ethnology has no affinities with the natural or biological sciences.

The book is well documented and indexed.



DIE TRÄGER DER KULTUR.

By Walter Scheidt. *Alfred Metzner, Berlin.* 4.50 marks. 8 $\frac{3}{8}$ x 5 $\frac{1}{2}$; 131; 1934.

This book embodies the content of a lecture course on eugenics given for a number of years at the University of Hamburg. Its approach differs somewhat from that of the conventional English and American treatises on eugenics. The nucleus of the argument is the national culture of the German people, and what the author discusses are the biological factors that condition it, and in a statistical sense determine it. The general conclusion reached is pessimistic. In the 70 years from 1930 to 2000 the author predicts that the combined percentage in the population of the highly gifted, those above the average, and those of average gifts, will decline from 67 percent to 47 percent, and the proportion of inferior folk correspondingly increase. The book has no index and few bibliographic citations.

HISTORY OF PALESTINE. *The Last Two Thousand Years.*

By Jacob de Haas. *The Macmillan Co., New York.* \$3.50. 8½ x 5½; xxvii + 523; 1934.

In the introduction of this book the author says:

The history of the country, as a whole, and of particular places, has been one of alternating violent or gradual change. Mutation, in all things, has been the keynote of Palestinian history these two thousand years. It could not well be otherwise, for no other land has been so forced to obey the whim of conqueror; or has been the meeting place of so many diverse races and peoples.

Three world religions have been born here and a fourth, that of the Druzes, persisted for a thousand years. In spite of the wars that repeatedly swept over the country from the time of the Roman conquest in the year 70 up to the advent of the Turk the country long remained enormously rich in its agricultural products. Its centers of population had a high mobility induced by the ever changing political, social and economic conditions. By the middle of the thirteenth century the disintegration of Palestine had commenced. A subjugated land, misruled by its masters, its forests destroyed by invaders, its people crushed by plague and epidemic, it gradually became more like the desert waste around it. Its cities fell into decay and its rural regions became desolate. For five hundred years this decay continued. From the time of the discovery of America, Palestine became an almost forgotten country. With a few notable exceptions the buildings of present day Palestine are less than three centuries old. The author of this volume has traced with meticulous care the important events of Palestinian history. Written without bias the student will find it a useful reference book. The general reader will find it absorbingly interesting. The chapters are documented and there is a detailed index.



THE TWILIGHT OF PARENTHOOD.

By Enid Charles. *W. W. Norton and Co., New York.* \$2.50. 7½ x 5½; vii + 226; 1934.

Dr. Charles belongs to the newer school of writers on population who view with alarm, not the prospect of overpopulation, as did the followers of Malthus, but rather that of population decline. As Dublin and Lotka have pointed out, the decline of the birth rate has resulted in an excess of women of the child bearing ages, so that even if the decline in the birth rates at ages should cease, the crude birth rate would continue to decrease until a stable age distribution was reached. In this way a population which is actually increasing at the present time may be potentially stationary or even decreasing, and Kuczynski has found that a number of European countries are already in this potentially decreasing state. Incidentally, in her exposition of the newer methods of demographic statistics Dr. Charles gives rather the impression that these are due almost entirely to Kuczynski. Actually the net reproduction rate was first used by Boeckh, while the development of the mathematical analysis of the dynamics of population is mainly due to Lotka.

In the discussion of whether the observed decline in the birth rate is the result of increase in density of population, as Pearl has concluded, or of some special cause such as the spread of contraception, it is scarcely correct to say that "Pearl himself was unable to offer any explanation of the fall in fertility observed in *Drosophila*." The latter has found evidence "that crowding produces the observed effect on rate of egg laying primarily, though probably not solely, as a result of a collision or interference action of the flies upon each other, which alters the normal physiological equilibrium and processes of the individual. . . ." Nor is the inverse relation between density and fertility confined to *Drosophila*. It has also been observed in the flour beetle, *Tribolium confusum*, through most of the density range, in fowls and in human populations.



BENJAMIN RUSH, PHYSICIAN AND CITIZEN, 1746-1813.

By Nathan G. Goodman. *University of Pennsylvania Press, Philadelphia.* \$4.00. 9 x 5½; 421; 1934.

It is unfortunate that this first full biography of Benjamin Rush is not always well presented. The author, however, has been tireless in his research and has accumulated a large amount of authentic material concerning this great physician, patriot and reformer. In so brief a review it is possible to indicate only a few of Rush's many interests. He did not confine his attention solely to medicine, although in this field he was a pioneer along many lines. One of the first advocates of preventive medicine, the first American psychiatrist and the first formal professor of chemistry, the founder of the free dispensary in Philadelphia and of the College of Physicians, he still found time faithfully to attend to his extensive practice and to write numerous treatises on a wide variety of topics. Both his book on mental disease (a classic for 50 years) and his chemistry were the first of their kind to be produced in this country. His interest in social reform led him to found the first temperance and anti-slavery societies, the first Sunday school system, and Dickinson College. A signer of the Declaration of Independence, his patriotism was intense and if during the Revolutionary period he made many bitter enemies no one ever accused him of selfish motives. All students of medicine and public health will find this an absorbing book but it will be equally interesting to the general reader who will find in Benjamin Rush another of those great figures who helped to mould the destiny of our country. The volume contains a few illustrations, collections of notes, a lengthy bibliography and an index.



MEDICINE MAN IN CHINA.

By A. Gervais. Translated from the French by Vincent Sheean. Frederick A. Stokes Co., New York. \$2.75. 8½ x 5½; 336; 1934.

Dr. Gervais, a French physician, gives an intimate portrait of China, particularly around Chengtu in the western part of the country. His attempts to practise medicine in the European manner and the uselessness of combatting dirt and disease in a race that lives apparently unconscious of the former and resigned to the latter are

well portrayed. The following are examples of what the physician is obliged to cope with: "Have you any fever?" "Yes, in the palm of my left hand." To a woman: "What is troubling you?" "I lost my son last year and I've caught the sickness of sadness. Give me a remedy." To another: "What are your pains?" "I am not ill. I only want to know if I am strong enough to take a bath."

When a class in dissection was started, the townspeople mobbed the classroom. The Chinese governor, eager to promote the cause of medical education, proposed that the next dissection should be performed upon a live criminal. To dissect a cadaver was to profane the dead; to dissect a living subject was merely a new and ingenious mode of execution. Unfortunately, though this solution satisfied the Chinese mores, it did not satisfy Dr. Gervais' European mores.

The author gives many vivid examples of the vast differences between the Chinese and Western ideas of law, honesty, cleanliness, sickness, marriage and death. From these we receive a feeling of futility in even attempting to change a race so different in background and so utterly absorbed in past tradition. We begin to realize that it is not a matter of months and years but of generation upon generation before Western ideas of progress are even partially understood.



SPARKS BENEATH THE ASHES. *Experiences of a London Probation Officer.*

By Mary Ellison. John Murray, London. 6 shillings. 7½ x 4½; xvi + 240; 1934.

A book that all those interested in social welfare should not fail to read. It recounts the experience of a probation officer in the slums of London. Her case histories are most interesting. But even more interesting to the reader will be what this book quite unconsciously reveals of the author herself. Probably comparatively few social workers have the wisdom, discernment, and humor that Mrs. Ellison has. In her preface the writer (Mary Stopford before her recent marriage) says:

Some maintain that the balance has swung too far in favour of the individual in England to-day and that sentimentality is ruining the administration of justice. This is sometimes true. The actual selection of the individual may be wrong. It is unwise to force probation on one who does not wish for it, as, for example, on a prostitute unwilling to abandon her mode of life. To do so is unfair to the Act, to the Probation Officer and to the woman herself.

Mrs. Ellison's office was her home in a basement flat in Pimlico and at all times the door was open. This she believes is essential to successful welfare work. Troubles cannot always wait for the office door to open at ten o'clock in the morning. "... immediate action at the psychological moment may turn the complete tragedy of to-morrow into the successful start of a new life." The various chapter headings of the volume are as follows: A day's work; Life in the slums; Stray sheep; Gangs, gangsters and thieves; Family differences; Queer people and dear people; Drunkards, drug addicts, suicides; Women of the streets—the broken-hearted. The volume is not indexed.



RICHARD TREVITHICK, *the Engineer and the Man*.

By H. W. Dickinson and Arthur Titley. University Press, Cambridge; Macmillan Co., New York. \$5.50. 9½ x 6½; xvii + 290 + 18 plates + folding pedigree chart; 1934.

Richard Trevithick is one of the great engineers of all times. Possessing a brilliant but erratic mind he had little theoretical knowledge upon which to base his inventions. His ideas came to him with the rapidity of intuition. No sooner were they conceived than were they put into execution with lightning-like speed. Watt was the inductive philosopher developing his low pressure theories with slow and meticulous care. About 20 years after he had introduced his engine into Cornwall Trevithick, still under 30, developed almost over night his high pressure steam engine, the forerunner of our boilers and turbines of today. It is unfortunate that so little is known of the eleven years that the inventor spent in South America, where he went to install his engines in the great silver mines of Peru.

The authors have based their book on the two large but somewhat obscure volumes which Trevithick's son Francis produced some 60 years ago, adding new material that has come into their possession. They have made an extremely interesting book both for the general reader and for the engineer. The volume is abundantly illustrated with reproductions of Trevithick's drawings, contains a list of the inventor's patents for inventions, a pedigree of his family, a bibliography and an index. It has been issued as a memorial volume on the centenary of the death of the great engineer.



TIMBUCTOO.

By Leland Hall. *The Cresset Press, London*. 8s. 6d. net. 8½ x 5½; xiii + 278; 1934.

SALAH AND HIS AMERICAN.

By Leland Hall. *Alfred A. Knopf, New York*. \$2.00. 7½ x 5; 199; 1934.

Both of these books are entertaining. *Timbuctoo* reveals much of the native life and customs of the French Sudan. *Salah and his American* centers around one person, the negro lad (a former slave) who attached himself to the author in Casablanca and made himself part of the author's life for a brief period. At the time of parting Salah was provided with a way of making his living but Mr. Hall had many doubts of the wisdom of this which meant for the gentle and honest Salah battling with dishonest and unscrupulous people and the ultimate breaking down of his fine character. In slavery 'Salah's chances for what we call happiness—chances which are seldom for us to fight over or relinquish—would be favorable."

In *Timbuctoo* which is south of Morocco on the opposite edge of the Sahara desert the author established a home for himself, acquired servants and mingled with the natives. He writes of the many friends that he made; the return of the great salt caravan when over a thousand Arabs and their camels poured into Timbuctoo after several months in the desert; of the ancient university and mosques; of the Songhai who trained in literary Arabic and French maintain their ancient tradi-

tion and exhibit a "notable elegance of manner." He does not mention, however, Père Yakouba, the "white monk" of Timbuctoo, and the reader naturally wonders why not? The very few illustrations in the books are sufficient since Mr. Hall's word pictures are vivid and colorful. Neither volume is indexed.



EARNINGS AND STANDARD OF LIVING OF 1,000 RAILWAY EMPLOYEES DURING THE DEPRESSION. U. S. Department of Labor.

By Carter Goodrich. U. S. Government Printing Office, Washington. 10 cents.

9½ x 5½; vi + 56 + 2 plates; 1934 (paper).

This pamphlet, unlike the majority of reports dealing with the recent economic depression, has to do, not with the unemployed, but with a group of workers who still held their jobs through the worst months of 1933. Such a group is a highly selected one but represents a large and very important class of workers whose reactions to the depression are but little known. The survey shows that the depression brought to these railroad men and their families a much greater reduction in net income than is generally appreciated. Taking account of all available sources of income only one quarter of them received in 1932, as much as \$1,750 per year; nearly 60 per cent received less than \$1,500. Study of the attempts of these families to manage their financial affairs revealed that few had cut down on their obligations. Many gave generously to needier families; more than a fifth took less fortunate relatives or friends into their own homes. Only 72 (out of the 1,000) received aid from public or private relief agencies. Attempts to economize include the abandonment of educational opportunities, large reductions in expenditures for food and clothing, almost complete curtailment of even the most inexpensive forms of recreation, and dangerous neglect of health needs. Despite these economies, the cash savings of most of the families were completely exhausted, many had lost their homes, half of them report sacrifice of insurance policies, and nearly 60 per cent had gone seriously into debt.

REBEL DESTINY. Among the Bush Negroes of Dutch Guiana.

By Melville J. and Frances S. Herskovits. Whittlesey House, McGraw-Hill Book Co., New York. \$3.00. 9 x 5½; xvii + 366 + 15 plates; 1934.

More than a century and a half ago slaves imported into Dutch Guiana revolted and escaped to the bush which lies to the north of the Amazon basin, where they established a "Little Africa." Protected from molestation by the whites by treacherous rivers and the dense jungles they increased in numbers and in course of time were given their freedom by the Dutch. Of the three tribes which then became free the Saramacca has had the least contact with outside influences and has preserved to a marked degree tribal customs and beliefs which their ancestors brought with them from Africa. It is this tribe with which the present volume deals. In their treatise the authors have stressed the "Bush Negro's attitudes towards his own civilization and his own logic in explaining his customs." It is an absorbing book which the general reader will do well to include in his reading list. The illustrations are well chosen, those displaying the artistry of the tribe being particularly interesting. Included in the volume is a section on glossary and linguistic notes and an index. The scientific discussion of the ethnological data and the comparison of the Bush Negro with other negro groups in the New World have been reserved by the authors for other publication. The completed study forms part of a general investigation which the authors are making on the physical and cultural characteristics of the negro of the New World.



AN INTRODUCTION TO PARETO, HIS SOCIOLOGY.

By George C. Homans and Charles P. Curtis, Jr. Alfred A. Knopf, New York.

\$2.50. 7½ x 5; xiii + 299 + vi; 1934. The authors are to be complimented for their courage in attempting to "popularize" the Sociology of Vilfredo Pareto. Except for some changes in nomenclature and a substitution of illustrative examples

they have remained faithful to the original. "Residues," "Derivations," etc. are very clearly defined. It is no mean task to summarize intelligibly Pareto's monumental work in the brief space used by the authors and whatever weakness there results should be condoned. We dislike, though, the repeated assertions of the mathematical difficulties encountered in the original. Actually, except in rare instances, Pareto makes use of procedures familiar to most college students.

As Pareto repeatedly stated, the authors have emphasized that in the analysis of "teorie non-logicosperimentali" by means of "Residues" and "Derivations," the various categories of these are only tentative; the same is to be said for their application to the study of the movement of social classes. This should serve as a spur to a revision, reclassification and extension of the categories and method by serious students of social sciences and human biology not hampered by prejudices, political, ethical, or religious. It is to be hoped that this book will serve such a purpose.



THE PRAIRIE PROVINCE OF ILLINOIS. *A Study of Human Adjustment to the Natural Environment. Illinois Studies in the Social Sciences, Vol. 19, No. 3.*

By Edith M. Poggi. University of Illinois Press, Urbana. \$1.00. 10½ x 7; 124; 1934 (paper).

An interesting study in human adjustment to natural environment which the investigator has worked out with considerable detail. The survey includes numerous maps and tables, a lengthy literature list and an index.

This study represents an attempt to discern the character and influence of the various elements of the natural environment—topography, soil, climate, vegetation, mineral resources, and location—upon the settlement and development of the prairie province of east-central Illinois, and to determine the extent of man's adjustment to these environmental conditions. Following the introductory chapter on the geographic regions of Illinois, the first part of the study consists of five chapters on the physical setting of the prairie province; the second part deals with agriculture and mineral industries as major human adjustments; and the third part is an interpretation of the geographic and economic conditions influencing settlement and development.

WHAT ABOUT ALCOHOL? *An Illustrated Outline of Scientific Facts about Alcohol and Alcohol Drinking.*

By Emil Bogen and Lehmman W. S. Hisey. Scientific Education Publishers, Los Angeles.

\$1.50. 9½ x 6½; ix + 112; 1934.

The conclusions of this volume, all of which, according to the authors (with whom we cannot whole-heartedly agree on the point) have been proven true, are as follows:

Alcohol is a clear liquid formed by fermentation of vegetable matter. It is quickly absorbed but slowly burned up in the body. It cannot build or repair the tissues. It makes the drinker feel warm, but really lowers his temperature. It weakens muscular control and makes the drinker tire more quickly. It dulls the senses and depresses the mind, causing loss of self-control. It is not a good medicine for many sicknesses for which it has been used. It may, instead, cause many sicknesses and make other sicknesses worse. Large amounts of alcohol cause drunkenness, but even moderate drinking has its dangers. The use of alcohol causes much expense and loss to the entire community.

Despite the fact that the authors claim to be presenting facts only in the book this reviewer entertains an ignoble feeling that the book is really motivated by the reformers' spirit and is, in effect, intended to be propaganda against alcoholic imbibition. The illustrations are supposed to provoke laughter: the reviewer was antagonized by them.



VIE ET RAJEUNISSEMENT. *Une Nouvelle Méthode Générale de Traitement et Mes Expériences de Rajeunissement de Bologne et de Paris.*

By Francesco Cavazzi. Gaston Doin et Cie, Paris. 22 francs. 10 x 6½; xii + 73 + 17 folding plates; 1934 (paper).

This monograph consists essentially of two papers read before the Société de Médecine de Paris reporting the results of experiments on rejuvenation. The procedure, derived from an idea of Brown-Séquard, is that of repeated subcutaneous injections of "efferent testicular blood" taken from young and healthy horses. The experimental subjects were two groups of aged men, respectively of Bologna and Paris. The results were, so it is said, a return of vigor and strength, physical and spiritual. These effects the

author attributes to a testicular hormone which he is able to obtain at its source.

Not content with the exposition of such amazing results the author feels the necessity of introducing at every available point remarks of a personal nature, to tell the story of his failure in obtaining recognition in Bologna and to praise the somewhat better reception of the French. This effort to obtain sympathy for himself detracts much from whatever scientific value is to be attached to the results.

There is a laudatory preface by Ch. Richet and several very guarded testimonials by well known French physicians and physiologists.



THE RAINBOW BRIDGE. *A Study of Paganism.*

By John S. Newberry. Houghton Mifflin Co., Boston. \$3.75. 8½ x 6; xv + 346; 1934.

This tale "of beasts and men and demigods and gods traces the history of paganism from the Stone Age to the Age of Perikles." The author has undertaken to

analyze the ideas that formed the basis of the religious cults of the cavemen, the Sumerians, the Chinese and Japanese, the Hindus, the Egyptians, the Persians, the Hebrews, the Phrygians, and the Greeks, and to co-ordinate these different racial attempts to exploit the supernatural, thus showing how the beliefs of the savage evolved into the creed of the most enlightened race of ancient times, and to establish the relation between the religious impulse and the rise of literature.

It is an interesting book that the author has given us. If at times he seems to be building upon insufficient evidence, at least the reader will acknowledge that he has done his best with available material. His work shows evidence of wide research and a painstaking accumulation of facts. Extensive notes are grouped together by chapter headings at the end of the volume and there is an index.



CHARLES W. ABEL OF KWATO. *Forty Years in Dark Papua.*

By Russell W. Abel. Fleming H. Revell Co., New York. \$2.00. 8 x 5½; 255; 1934.

This biography, written by one of his sons, is the story of Abel's efforts to convert, with considerable success, the Papuan cannibals into Christians. The first part of the book, concerning the setting up and early years of the mission is the more interesting, interspersed as it is with bits such as the following:

"The true food for man!" old cannibals still avow—and they add that only of human flesh can one eat to excess without unpleasant after effects. Nevertheless, the people of this eastern part of New Guinea did not eat the flesh of their enemies either for pleasure or merely for a change of diet. The feast was a religious ceremony, expressing revenge and absolving them of a duty to their wronged dead. Those who partook thereby vindicated their reputation and disgraced the tribal kindred of those who were eaten. The spirits played their part in cannibalism, as in all else in Papuan life.

The latter part is concerned too much with the efforts to raise funds for the mission and the establishment of industrial enterprises. The book, however, gives a good picture of Abel's amazing energy, sense of humor, and a broadmindedness not usually associated with missionaries. Before teaching the natives Christianity he taught them cricket.



LAW AND ORDER IN POLYNESIA. *A Study of Primitive Legal Institutions.*

By H. Ian Hogbin. Harcourt Brace and Co., New York. \$5.00. 8½ x 5½; lxxii + 296 + 8 plates; 1934.

Since most primitive tribes have no such differentiated legal institutions as judges and policemen many anthropologists have been led to the conclusion that these tribes have no law or at most only criminal law. According to these writers the savage is still too dumb to even think of breaking the customs of his tribe. Malinowski, however, in his more intimate first hand study of the Trobriand Islanders found a more complex mechanism, which is confirmed by his pupil Hogbin for the Polynesians of Ontong Java. The people of these tribes "keep to what custom—or, more correctly, law—bids them to do because they know that not far ahead there looms the occasion when in the name of the same law they will be entitled to demand the counter-service." If a wife

refuses to cook and tend her taro garden her husband will refuse to supply her with fish and vice versa. The spirits of the dead are also supposed to punish infractions of obligation. Moreover the injured party may hire a sorcerer to work his spells on the offender. Thus, although no courts enforce private obligations, there are advantages to those who fulfill their customary duties and corresponding disadvantages for those who do not.



HABITAT, ECONOMY AND SOCIETY: A Geographical Introduction to Ethnology.

By C. Daryll Forde. Methuen and Co., London. 15 shillings net. $8\frac{1}{2} \times 5\frac{1}{2}$; xiv + 500; 1934.

By the simple expedient of an ordered and clear description of the economic, social and religious customs of "primitive" peoples (Bushmen, Eskimos, Boroos, Samoans, Kazaks, etc.) the author definitely reaffirms what, though well-established, is not always admitted; i.e., that physical environment is not the only factor in determining the type of economic civilization. In the first three chapters, each dedicated respectively to food gatherers, cultivators, and pastoral peoples, one observes peoples of different economics in the same environment and *vice versa*. A fourth chapter synthesizes the preceding and reviews the different economics with regard to particular historical and geographic background. The final conclusion is, as has been in part mentioned, that economic, social, geographic conditions are so intimately interrelated that we cannot speak of one as being the cause or effect of the others. A well written book with an extensive bibliography and very appropriate for students of ethnology.



THE PROBLEM OF THE AUSTRALIAN ABORIGINAL.

By E. R. B. Gribble. Angus and Robertson, Sydney. 5 shillings. $7\frac{1}{4} \times 4\frac{1}{2}$; xv + 157; 1932.

In order to save the still-existing aboriginal tribes of Australia from the fate of the Tasmanians, or worse, the Reverend

Gribble advocates their segregation on reservations similar to those for the Indians of this country. He furthermore recommends that their teaching be put in the hands of Christian missions rather than Government stations in order that the inculcation of christian ethics may counteract the vices they may have learned from the whites.

The book contains a deal of information, which may interest the anthropologist, concerning those tribes with which the author worked. There is also an unpleasant chapter on "Our treatment of the race," and one on the history of missionary efforts. We like this sentence concerning the Lutheran Society of Dresden.

"They laboured with much patience and great zeal, but after some years of toil and self-denial, abandoned the work among the natives, and undertook work amongst the white settlers."



THE RISE AND FALL OF THE CHOCTAW REPUBLIC.

By Angie Debo. University of Oklahoma Press, Norman. \$3.50. 9×6 ; xvii + 314 + 26 plates; 1934.

The aboriginal Choctaws were a mild, quiet and kindly people. Being practical minded and adaptable they readily acquired the customs of the more advanced peoples with which they came in contact. The history of their race, and particularly of their relations with the United States Government is an exceedingly interesting one, but not one that the white race can be especially proud of. Land-hungry settlers assisted by the government devised every means possible to force the Indian race out of their fertile lands in the Mississippi regions to the more remote and supposedly less valuable lands further to the northwest. From the Civil War to the close of the century there was one continuous struggle of the Choctaw race to maintain its institutions and autonomous government. Miss Debo tells the story in great detail and has documented all of her points. The volume contains a number of maps and photographic reproductions, a lengthy bibliography, and is well indexed. The study is the sixth in the *Civilization of the American Indian*

series published by the University of Oklahoma Press.



HISTORY OF ANTHROPOLOGY. *The Thinker's Library*, No. 42.

By Alfred C. Haddon. Watts and Co., London. 1 shilling net. 6½ x 4; xiv + 146; 1934.

This little volume, No. 42 of the Thinker's Library (British), can scarcely be considered a second edition of the author's first *History of Anthropology*, since it is made up of practically new matter. For its size it contains a great deal of interesting material. The author points out that more attention has been given to armchair workers than to field workers since he is dealing chiefly with "generalizations which proceed mainly from arm chairs." The three main sections of the book are human biology, cultural anthropology or ethnology, and comparative sociology. The literature cited is not detailed but sufficient for the student. There are a number of illustrations, and an author's index but no general index.



ERBLEHRE UND RASSENHYGIENE IM VÖLKISCHEN STAAT.

Edited by Ernst Rüdin. J. F. Lehmann, Munich. 14 marks (paper); 16 marks (cloth). 9½ x 6½; viii + 385; 1934.

The results of a symposium on mental and race hygiene held in Munich, January 1934, are set forth in 22 articles by 19 authors, on genetics, race origins, eugenics, and sterilization problems. The first article by the Bavarian Minister of Interior, concerning the value of race-hygiene for the state, is highly political. In fact there is hardly one of the articles which does not mention Hitler once or twice. There are two extra good chapters, however—one on the hereditary basis for race hygiene, incidentally written by a botanist; and the chapter on race origins written by Mollison, the latter being politically less biased than any of the other authors. There is however an unfortunate tendency throughout the book

to portray scientific facts chiefly in their relation to the present German political beliefs.



CENSUS OF 1930 IN NETHERLANDS-INDIA. Volume II. *Native Population in Middle-Java and the Native States of Java*. Volume III. *Native Population in East-Java*.

Census Office, 11 Schoolweg, Batavia-Centrum, Java, Netherlands-India. Vol. II, f. 8, Vol. III, f. 6. 13½ x 9½; Vol. II, xx + 256 + folding map; Vol. III, xvii + 222 + folding map; 1934 (paper).

The census official in Java has certain difficulties which do not trouble his brother in the Occident. Thus so few of the Javanese know their exact age that the population has been tabulated in three age classes: (1) infants not yet able to walk, (2) other non-adults, (3) adults. The boundary between classes 1 and 2 was easy to determine but that between classes 2 and 3 presented more difficulty. The criterion adopted was that a girl was adult when she was marriageable and a boy when he was physically able to go to work. However, in districts where it is the custom for girls to be married before puberty the enumerators, even though instructed that not all married girls need be adult, tended to disregard this instruction.

Another item with which Occidental census officials do not have to deal was number of simultaneous or concurrent wives. It was found that only 2 per cent of the married men had more than one wife at the same time.



A CONTRIBUTION TO THE ARCHÆOLOGY OF NORTH-EAST GREENLAND. *Skrifter om Svalbard og Ishavet*, Nr. 63. *Det Kongelige Departement for Handel, Sjøfart, Industri, Håndverk og Fiskeri. Norges Svalbard- og Ishaus-Undersøkelser*.

By Søren Røchter. *Kommisjon Hos Jacob Dybwad, Oslo*. Kr. 25. 10½ x 8½; 149; 1934 (paper).

During 1929-31 the author was a member of the Norwegian Hunting Expedition in

North-East Greenland, and in the summers of 1932 and 1933 covered the same terrain with the Norwegian Greenland Expedition. In this work he tells about his explorations, beginning with a description of the country and continuing with his "finds"—remains of settlement and artefacts of various periods; hunting requisites, tools, household utensils, etc. Due to the sparsity of settlements found, and the small size of these, he concludes that this region never had a large Eskimo population. The treatise is profusely illustrated, and a list of sites is appended.



DER WIENERWALD. *Eine Landeskundliche Darstellung. Forschungen zur Landeskunde von Niederösterreich Band 1/2.*

By Anton Schachinger. Ferdinand Berger, Horn. 9½ x 6½; viii + 510 + 18 plates; 1934 (paper).

Beginning with the geological structure of the Wienerwald, its topography, climate, fauna and flora (all of which are covered in the first 82 pages), the author proceeds with the history of the populations inhabiting it. He traces the vicissitudes of the people and their culture from prehistoric times through the Roman period and the various Magyar and Turkish invasions, to the present. Information concerning religious history, plans of towns, constructions of roads, industries, etc. are given. It is a detailed, scholarly, well-documented work. It is illustrated with photographs and several maps, and has an index of place names.



HUMAN STERILIZATION TO-DAY. *A Survey of the Present Position.*

By Cora B. S. Hodson. Watts and Co., London. 1 shilling (cloth); 7d. (paper).

7½ x 4½; vii + 56; 1934.

An ardent but on the whole sane plea for permissive sterilization. The first chapter consists of a good explanation, for the lay reader to whom the book is addressed, of eugenic sterilization. The author has visited many places where eugenic sterilization is being done and reports some of

these in considerable detail. Throughout the book no inkling is given that the determination of the hereditary aspect of any defect may not be easy and clear cut.



THE LUMMI INDIANS OF NORTHWEST WASHINGTON.

By Bernhard J. Stern. Columbia University Press, New York. \$2.00. 10 x 6½; 125 + 6 plates; 1934.

The Lummi Indians are now settled on a reservation near the Canadian border in northwestern Washington. Because of the tribe's geographic isolation the Lummi culture has remained quite intact and the present studies are based on ethnological material collected in 1928-29. The book is divided into three parts: Part 1, dealing with the cycle of life and describing important stages in the development and relationships of the individual, relative to his fellows; Part 2, entitled "Tribal Culture" describing many of the customs and activities of the Lummi society, and Part 3, depicting the legends and lore of these people. This is an interesting and valuable contribution to American Indian ethnology.



RACIAL CONTACTS AND SOCIAL RESEARCH. *Papers Presented at the Twenty-eighth Annual Meeting of the American Sociological Society, Held at Philadelphia, Pennsylvania, December 27-30, 1933. Volume XXVIII, The American Sociological Society.*

The American Sociological Society. The University of Chicago Press, Chicago. \$1.50. 9½ x 6½; viii + 129; 1934 (paper).

A group of some 68 papers on various sociological problems by American sociologists presented at the twenty-eighth annual meeting of the American Sociological Society. Reports are made from sections of: Human Ecology, Social Psychology, Social Institutions, Rural Sociology, Teaching of Sociology, The Community, Sociology of Religion, Social Work, Social Statistics, Educational Sociology, The Family, and Sociology and Psychiatry.

THE RACIAL MYTH.

By Paul Radin. Whittlesey House, McGraw-Hill Book Co., New York. \$1.50.

7 $\frac{3}{4}$ x 5; ix + 141; 1934.

In this book Professor Radin of the Department of Anthropology of the University of California ridicules the idea that the development of civilization is bound up with any one race. Neanderthal man, who first invented stone implements, was probably not an ancestor of any of our present races. The inventors of pottery were members of the white race; the Egyptians, a mixed white race, invented glass and the Chinese invented porcelain. And so it goes. The development of civilization is an inextricably interwoven record of the achievements of many races.



THE JEW IN SCIENCE.

By Louis Gershenfeld. The Jewish Publication Society of America, Philadelphia.

\$2.75. 8 $\frac{1}{2}$ x 5 $\frac{3}{8}$; vii + 224; 1934.

About half of this book is devoted to short biographical lists of Jewish scientists of modern times in the various scientific fields. The rest of the space is concerned with the relation of Jewish people to national development up to and through the Renaissance. The author hopes to change distorted views about the Jew in science and to encourage a desire among Jews to learn something of their brethren in the scientific field. The book has therefore at times a slightly propagandist tone that is somewhat irritating.



THE LIFE OF SIR ROBERT JONES.

By Frederick Watson. William Wood & Co., Baltimore. \$3.75. 8 $\frac{3}{4}$ x 5 $\frac{1}{2}$; 327 + 10 plates; 1934.

A charming man Sir Robert must have been, but hard to keep up with. The amount of work this famous orthopedic surgeon managed to accomplish was almost superhuman. His associates and colleagues must have been exceptional to make such feats possible although little is said of that. The early chapters show-

ing the influence of his father and uncle on the young man are particularly entertaining.



A VOYAGE ON THE SEALER EMELINE AND THE JOURNAL. From Washington Fosdick's Manuscript Preserved in the Museum of the Old Dartmouth Historical Society at New Bedford. *Zoologica*, Vol. 9, No. 14.

Edited by Arthur C. Watton. New York Zoological Society, New York. 85 cents net. 9 $\frac{1}{2}$ x 6 $\frac{1}{2}$; 75; 1931 (paper).

Interesting alike to the biologist and the student of Americana. To the former because of the information on the numbers and habits of seals in the 1840's; to the latter because of the side-lights it gives us in these effete times on what men could do. The cold, wetness, and general hard work involved in procuring seal oil is almost unbelievable.



THE YOUTH OF OLD AGE.

By Johnson Brigham. Marshall Jones Co., Boston. \$2.50. 8 x 5 $\frac{3}{8}$; xvi + 209; 1934.

The author of this anthology that isn't an anthology was born in 1846 and he feels strongly that old age need not be the bleak and distasteful thing most people believe inevitable. To bolster up his own courage, perhaps, he has here gathered together all sorts of quotations dealing with the delights and benefits of advancing years. There is as much of Brigham's comment about the authors quoted as there is actual quotation.



A BIBLIOGRAPHY OF GILBERT WHITE. *The Naturalist and Antiquarian of Selborne. With a Biography and a descriptive Account of the Village of Selborne.*

By Edward A. Martin. Halton and Company, London. 10s. 6d. 8 $\frac{1}{2}$ x 5 $\frac{3}{8}$; viii + 195; 1934.

In this enlarged and revised edition the bibliography is brought up to date and two pen and ink sketches of White, found in his copy of Pope's *Iliad*, are reproduced.

QUARTERLY BULLETIN OF THE HEALTH ORGANISATION, *League of Nations*, Vol. 3, Nos. 1 and 2.

World Peace Foundation, 40 Mt. Vernon St., Boston; *League of Nations*, Geneva. 65 cents each (subscription \$2.50 per year) (U. S. A.); 2 shillings each (10 shillings per year) (Geneva). 9½ x 6½; No. 1, 155; No. 2, 168 + 13 plates; 1934 (paper).



ZOOLOGY

THE WOOD-FEEDING ROACH *CRYPTOCERCUS*, *Its Protozoa, and the Symbiosis between Protozoa and Roach*. *Memoirs of the American Academy of Arts and Sciences*, Vol. 17, No. 2.

By L. R. Cleveland, In collaboration with S. R. Hall, Elizabeth P. Sanders, and Jane Collier. *George Banta Publishing Co., Menasha, Wisconsin*. \$6.50. 11½ x 9½; x + 160 + 60 plates; 1934.

For approximately the last decade Cleveland has been describing the symbiotic relationships between cellulose-feeding termites and their cellulose-digesting intestinal flagellates. In the present monograph he extends his researches by studying the same problem for the wood-feeding roach *Cryptocercus punctilatus* Scudder. The latter organism is a happy choice due to its phylogenetic affinities with the termites and to technical advantages, such as relatively large size, ease in laboratory breeding, etc. The following topics are dealt with in detail: first, the structure of the alimentary canal of the roach; second, a taxonomic and morphologic discussion of the intestinal flagellates of *Cryptocercus* including many interesting observations upon protozoan mitosis, and third, a consideration of the symbiosis between roach and protozoa. Under the last division Cleveland describes the techniques used in defaunating and reinfesting the roaches with their protozoa; the production and function of the protozoan-elaborated enzyme, cellulase, which digests cellulose into dextrose, and the way in which the dextrose is finally absorbed by the roach.

The problem is studied from the natural history as well as the experimental side,

which is a virtue. In discussing the experimental material one feels that more explicit statements as to number of cases and statistical significance of the results would be advantageous. On the whole, however, a large and important problem has been approached with interesting results presented and with new problems suggested.



THE FUR SEAL OF THE CALIFORNIA ISLANDS *With New Descriptive and Historical Matter*. *Zoologica*, Vol. 9, No. 12.

By Charles H. Townsend. *New York Zoological Society, New York*. 60 cents net. 9½ x 6½; 17; 1931 (paper).

THE FUR SEAL OF THE GALAPAGOS ISLANDS. *Zoologica*, Vol. 18, No. 2.

By Charles H. Townsend. *New York Zoological Society, New York*. 60 cents. (postage extra 5 cents). 10½ x 7; 14; 1934 (paper).

These two papers treat two southern fur seals which are now practically extinct. The first gives descriptive and historical matter concerning *Arctocephalus townsendi*. They inhabited the islands off the coast of Southern California and in the 1800's had a great commercial importance. However, little is known about them, and when the author was sent to Guadalupe Island in 1892 to identify the species he found but seven, although between 1876 and 1892 not less than 5,575 were reported taken from this and the San Benita Islands.

The *Arctocephalus galapagoensis* is the subject of the second paper. The text is brief and is based on several seals captured in 1932 and '33 and presented to the Zoological Garden at San Diego, California. These are the only specimens taken since 1906 when a single one was procured. The primary object of the paper was the publication of eleven photographs taken in San Diego, in order to show naturalists what this seal actually looked like.



REPTILES AND AMPHIBIANS. *Their Habits and Adaptations*. *Revised Edition*.

By Thomas Barbour. Illustrated in part by George Nelson. Houghton Mifflin Co., Boston. \$4.00. 9 x 5½; xx + 129 + 27 plates; 1934.

Regarding the first edition of this book we remarked (Volume 3, page 139) that it "is an example of the highest type of popular natural history writing" and there is no need to modify that opinion now. It is a splendidly arranged introduction to the principal characteristics of living reptiles and amphibians and to the variety of modifications of structure and behavior to be found in this group of animals and it is unusually well illustrated. It ought to accomplish its avowed purpose of turning the attention of naturalists to an interesting group of animals for which information on life histories is incomplete. There is an index and an annotated bibliography in which the merits and demerits of individual books, papers, and authors are mentioned with more than usual candor.



ANIMALIUM CAVERNARUM CATALOGUS. Part I.

By Benno Wolf. W. Junk, Berlin. 18 marks. 10 x 7½; xxiii + 112; 1934 (paper).

This catalogue of cavern fauna of the world will be issued in several numbers, each to be divided into three parts as follows: I. Bibliography; II. Catalogue of caves, large enough for man to enter, listed by continents and countries, with mention of the fauna found in each; III. Catalogue of fauna, taxonomically classified, with the caverns in which each is found given. The first number includes authors from A to Ch, caves in Belgium, Bulgaria, and Germany, and the phyla, Protozoa, Porifera, Coelenterata, Vermes, and Arthropoda. It is a very thorough and systematic piece of work.



THE COLLARED LIZARD: *A Laboratory Guide.*
By D. Dwight Davis. The Macmillan Company, New York. 90 cents. 7½ x 4½; viii + 57; 1934.

A laboratory manual dealing with the comparative morphology of the collared lizard, *Crotaphytus collaris*, of the south-western United States. About this form the author says;

I believe that the choice of the collared lizard as a representative of the class Reptilia is a happy one. Certainly the fundamental characters of the group are less masked by confusing specializations in the lizards than in any other of the common reptilian groups. This abundant terrestrial iguanid probably conforms as nearly to the ideal lacertilian type as any available form. Moreover, in size it is eminently suited to class dissection.



TROPICAL FISH & THEIR CARE.

By Norbert Lederer. Alfred A. Knopf, New York. \$2.50. 7½ x 5; xxi + 229; 1934.

Here is a book destined for piscatorial popularity; a concise and organized treatment of tropical fish and their problems. The book is planned for both immature and mature aquarists and deals with such problems as feeding, breeding, and tank equipment as well as presenting a discussion of the many kinds of tropical fish suitable for aquarium use. The reviewer will be pardoned if, in his ignorance, he fails to see how some of the therapeutic measures advocated for fish diseases can be successful.



GENERAL ZOOLOGY.

By Frederick H. Krecker. Henry Holt and Co., New York. \$3.50. 8½ x 5½; xi + 634; 1934.

Another text-book of zoology for first-year college students. There are four divisions to the subject matter; first, 'A typical animal'; second, 'A review of the animal kingdom'; third, 'Animals and their environment,' and, fourth, 'The origin of animals.' The volume is well illustrated. The chief merit of the book lies in its simplicity of statement and organization. As the author hopes, it probably will be useful in general zoology courses where the majority of the students merely wish biological orientation and are not interested in specialization.

LES INVERTÉBRÉS (*Calentérés et Vers*). *Actualités Scientifiques et Industrielles* 133. *Leçons de Zoologie et Biologie Générale*, III.

By Georges Bohm. Hermann et Cie, Paris. 15 francs. 10 x 6½; 102; 1934 (paper).

A text-book type of discussion of the coelenterates, sponges, annelids, platyhelminthes, nematodes, and aberrant worms. The reproductive and life-cycle aspects are stressed. The book is illustrated but not profusely so. The reviewer was not greatly impressed by this book. Much seems to have been lost by separating a few invertebrate phyla from their many relatives and reporting on them in so little detail. The volume can not be considered a reference work, and, due to the separation of the phyla, loses much of its value as a general zoological text.



GROWTH AND AGE IN THE GIANT TORTOISE OF THE GALAPAGOS. *Zoologica*, Vol. 9, No. 13.

By Charles H. Townsend. New York Zoological Society, New York. 35 cents net. 9½ x 6½; 16; 1931 (paper).

The principal conclusion is that:

The common supposition that large Galapagos tortoises must be of great age is unwarranted. Under natural conditions and especially under favorable climatic conditions in captivity, they reach a large size in a few years, when the rate of growth becomes slow. There are records of both Galapagos and Aldabra giant tortoises that lived under observation in tropical climates more than 150 years, when their lives ended upon removal to cold climates. The real length of life is unknown. Certain museum specimens known to have exceeded 500 pounds at death, were doubtless very old.



THE MOOSE OF ISLE ROYALE. *University of Michigan, Museum of Zoology, Miscellaneous Publications* No. 25.

By Adolph Murie. University of Michigan Press, Ann Arbor. 10 x 6½; 44 + 6 plates; 1934 (paper).

Although the author gives a good description of the moose and their behavior, as observed by himself, particular emphasis is placed on their feeding habits. They are so numerous on Isle Royale in Lake Superior that overbrowsing is general. In order to preserve the landscape the author recom-

mends drastic reduction of the moose population on the island and offers several suggestions for reducing the number. The pamphlet contains several photographs of the animals and their ravages on the vegetation.



THE WEASELS OF NEW YORK. *Their Natural History and Economic Status*.

By W. J. Hamilton, Jr. The University Press, Notre Dame, Ind. 9 x 6; 86; 1933 (paper).

This pamphlet, a reprint of a paper published in the *American Midland Naturalist* (Vol. 14, 1933) deals with two weasels found in New York State: *Mustela novboracensis*, commonly known as the New York weasel, and *Mustela cicognanii*, or Bonaparte. Besides a description of these species and their life history, there is a short section on the value of the weasel as a fur product, and as a rat and mouse predator, one on its care in captivity for study purposes, a bibliography and several illustrations.



ODDLY ENOUGH. "From Animal Land to Furtown."

By Arthur Samet. "Oddly Enough," 106 West 30th St., New York. \$2.00. 9½ x 6½; 200; 1934.

The author admits in the foreword that "this work is a curious study in furs," and that is, if anything, an understatement. The book is a jumble of elementary zoological facts, odd child-like pen and ink drawings, fairy tale references, and etymology written by a fur dealer. One feels the author is only on firm ground when he is discussing the classification of furs from the dealer's standpoint. Otherwise the book is of little merit.



GROWTH OF DIAMOND-BACK TERRAPINS: *Size Attained, Sex Ratio and Longevity*. *Zoologica*, Vol. 9, No. 25.

By Samuel F. Hildebrand. New York Zoological Society, New York. 20 cents net. 9½ x 6½; 13; 1932 (paper).

The size attained, sex ratio and longevity of the diamond backed terrapin is discussed briefly. In nature, this form frequently reaches a length as great as seven inches for the females. No precise data are available as to the length of life although the author, "regards the estimate of the highest age of forty years . . . as much too low."



THE NATURALIST ON THE PROWL.

By Frances Pitt. *The Macmillan Co., New York.* \$2.00. $7\frac{1}{2} \times 5\frac{1}{2}$; x + 137 + 33 plates; 1934.

Miss Pitt, an enthusiastic nature lover, gives much practical advice on the necessary equipment for studying wild life and on methods of observation. She also includes many of her own experiences with birds and beasts in her field work in the British Isles. The volume is well illustrated with the author's excellent photographs, contains a list of species mentioned (21 mammals, 73 birds, 2 insects) with scientific names and an index.



DIGITAL EPIPHYSES AND CARPAL BONES IN THE GROWING INFANT FEMALE GORILLA WITH SITTING HEIGHT, WEIGHT AND ESTIMATED AGE. *Zoologica*, Vol. 11, No. 5.

By Charles V. Noback. *New York Zoological Society, New York.* 90 cents net. $9\frac{1}{2} \times 6\frac{1}{2}$; 35; 1930 (paper).

The most prominent feature of this little pamphlet is the X-ray record of the growth changes in the bones of the hand of the gorilla. Certain other data on growth of the animals are also given. The work is based on five animals, one of which was living and was observed over two years time.



THE LITTORAL CRUSTACEAN FAUNA OF THE GALAPAGOS ISLANDS. Part II. *Anomura*. *Zoologica*, Vol. 14, No. 1.

By Lee Boone. *New York Zoological Society, New York.* 60 cents + postage. $9\frac{1}{2} \times 6\frac{1}{2}$; 62; 1932 (paper).

The author presents a description and illustration of every species of anomuran crustaceans known from the littoral zone

of the Galapagos Islands, including the larval forms of three species of Porcellanids which are the first American anomuran *Magalops* to be described.



TRAITÉ DE ZOOLOGIE. *Index Alphabétiques de l'Ouvrage Complet* (20 Fascicules).

By Edmond and Rémy Perrier. *Masson et Cie, Paris.* 40 francs. $10 \times 6\frac{1}{2}$; 163; 1933 (paper).

This index will be welcomed by those who already own the previous ten fascicules of this excellent reference series, several numbers of which have been noticed at various times in these columns. Two indices are contained in this number—one of technical terms and one of names of species and groups.



NOTES ON THE GILL-FINNED GOBY. *Bathygobius soporator* (Cuvier and Valenciennes).

By William Beebe. *New York Zoological Society, New York.* 40 cents net. $9\frac{1}{2} \times 6\frac{1}{2}$; 12; 1931 (paper).

The author sums up in his usual interesting manner, his observations on the goby, *Bathygobius soporator*. The pamphlet is illustrated by drawings, and a colored plate showing the color phases of this fish.



TROPICAL FISH.

By Lucile Q. Mann. *Leisure League of America, 30 Rockefeller Plaza, New York.* 25 cents. $8 \times 5\frac{1}{2}$; 99; 1934 (paper).

A real bargain, this. As much for twenty-five cents as could be found in a long day. This is really an excellent little treatise containing just the things an amateur wants to know about parlor fish and written in an extremely interesting and pleasing way.



CAVE LIFE OF KENTUCKY. *Mainly in the Mammoth Cave Region.*

By Vernon Bailey, with chapters on *The Birds*, by Florence M. Bailey, and on *The Invertebrates*, by Leonard Giovannoli. *The University Press, Notre Dame, Ind.* \$1.25. 9×6 ; 256; 1933.

An account of the life habits, appearance, numbers and frequency of occurrence, and a classification of the different species of mammals, birds, reptiles and amphibians found in the caves, with special reference to Mammoth Cave, Kentucky.



THE MAMMALS OF SOUTHERN NEVADA. *Transactions of the San Diego Society of Natural History*, Vol. 7, No. 36.

By William H. Burt. *Society of Natural History, San Diego, Calif.* 10½ x 6½; 53; 1934 (paper).

After a brief account of the physiography, floral and faunal relations in southern Nevada, the author presents a list of mammalian species, with descriptions, found in this region.



THE AMPHIBIANS OF KANSAS. *The American Midland Naturalist*, Vol. 15, No. 4.

By Hobart M. Smith. *University of Notre Dame, Notre Dame, Ind.* 35 cents. 9 x 6; 152; 1934 (paper).

A taxonomic discussion of the species of amphibians inhabiting the central plains region. Special consideration is given those found in Kansas.



NOTES ON SOME TYPES OF NORTH AMERICAN BIRDS. *Transactions of the San Diego Society of Natural History*, Vol. 7, No. 30.

By A. J. van Rossem. *Society of Natural History, San Diego, Calif.* 10½ x 6½; 15; 1934 (paper).

WEST AMERICAN SPECIES OF THE GENUS LIOTIA. *Transactions of the San Diego Society of Natural History*, Vol. 7, No. 37.

By A. M. Strong. *Society of Natural History, San Diego, Calif.* 10½ x 6½; 23; 1934 (paper).

A REVIEW OF THE RACES OF GEOCOCCYX VELOX. *Transactions of the San Diego Society of Natural History*, Vol. 7, No. 39.

By Robert T. Moors. *Society of Natural History, San Diego, Calif.* 10½ x 6½; 15; 1934 (paper).

THE PRIMITIVE PERSISTS IN BIRD LIFE OF YELLOWSTONE PARK, By George M. Wright. A WILDERNESS-USE TECHNIQUE, By Ben H.

Thompson. *The Condor*, Vol. 36, pp. 145-157.

Wild Life Division, National Park Service, Berkeley, Calif. 10½ x 7½; 12; 1934.



BOTANY

THE LIFE FORMS OF PLANTS AND STATISTICAL PLANT GEOGRAPHY. *Being the Collected Papers of C. Raunkiaer.*

Oxford University Press, New York. \$14.00. 9½ x 6½; xvi + 632 + 35 plates; 1934.

A valuable service has been rendered to ecologists by collecting Professor Raunkiaer's papers from the somewhat inaccessible journals in which they were published and in translating them from Danish into English, for his principles of classification of the life forms of plants will certainly be widely applied as they become better known. Raunkiaer's best-known scheme for statistical analysis of plant communities is to divide vascular plants into categories according to the amount and kind of protection afforded to the buds and shoot-apices. In his earlier work he recognizes ten categories, later only five: Phanerophytes, plants whose buds survive the unfavorable season freely exposed to the weather; Chamaephytes, whose buds are carried close to the ground; Hemicyptophytes, whose buds are situated in the soil surface; Cryptophytes, whose buds are buried in the soil; and Thero-phytes, which survive the unfavorable season as seeds. This forms a graded series "of which each successive member is on the whole better adapted to survive unfavorable seasons." He obtains a biological spectrum of the flora of a region by calculating the percentages of the flora that fall into the several classes, and this gives him a simple means of comparing one region with another, especially after he determined the distribution of forms in a random sample of 1000 species taken from the *Index Kewensis*.

Raunkiaer analyzed the floras of a large number of regions in this way and made valuable contributions to plant geography. All of his ecological work had a statistical basis and he developed many new procedures for obtaining numerical charac-

terizations of plant communities that deserve attention. The translation has been smoothly done, there are bibliographies, and there is a good index.



THE FAMILIES OF FLOWERING PLANTS. II. MONOCOTYLEDONS. *Arranged According to a New System Based on Their Probable Phylogeny.*

By J. Hutchinson. Macmillan and Co., London and New York. \$6.00. 8 $\frac{1}{2}$ x 5 $\frac{1}{2}$; xiii + 243; 1934.

This book is intended

to provide the student with descriptions of the families of Monocotyledons arranged in as logical a sequence as may be possible according to their probable phylogeny, starting with the most primitive and ending with the most advanced types. Some alterations in the status of a few of the families are proposed here for the first time, especially that of the *Amoryllidaceae* and of the *Liliaceae*.

The author proposes a system of classification which differs from the Engler and Prantl and other systems in more respects than we have space to mention and argues very persuasively for his point of view. The Monocots, which are considered to be monophyletic in origin and probably derived from the Ranales, are divided into three major groups on the basis of calyx and corolla characteristics: the Calyciferae have the Butomales and Alismatales as the most primitive members and the Bromeliales and Zingiberales as the most advanced; the Corolliferae begin with the Liliales and their allies and end in the Orchidales; and the Glumiflorae include the Juncals, Cyperales, and Graminales. The Liliales, in particular, have been thoroughly rearranged. This volume is constructed on the same principles as the first volume dealing with Dicotys previously reviewed (Volume I, p. 455) and, similarly, has natural and artificial keys to families, numerous illustrations of plants of phylogenetic importance, maps, and an index to families and genera. In this volume, in addition, there are keys to the genera of all families except the Gramineae and Orchidaceae, which add greatly to its usefulness. It is in every way an important book.

THE GRAMINEAE: *A Study of Cereal, Bamboo, and Grass.*

By Agnes Arber. Macmillan Co., New York. \$8.50. 9 $\frac{1}{2}$ x 6 $\frac{1}{2}$; xvii + 480; 1934. This comparative morphological study of the Gramineae is written by one of the foremost authorities in the field, and represents the results of careful examination, organ by organ, and tissue by tissue, of representative members of the order at every stage in their life history from seedling to flower, with the object of finding what peculiarities of structure and what modifications of function characterize the group as a whole. It is written in the style of Mrs. Arber's earlier monographs on the monocotyledons and the water plants and is as abundantly illustrated. Part of the material has been published in the *Annals of Botany*. This only half-way describes the book, however. One of the most significant things about the order is that man has depended on cereals, bamboo, and grass for food and shelter for himself and his domestic animals for as long a period as anything is known about human activities, and Mrs. Arber has set down the things about the relation of the grasses to man that, as she says, happened to interest her. This is a quaint form of understatement. Actually, she has drawn extensively from a wide variety of sources; the records of antiquity, herbals, traveler's accounts (particularly for information about bamboo), agronomy, and a number of other branches of science, and the result has been to make it a book of unusual interest and one that every biological library ought to have. There is an index and a bibliography that are models of completeness.



THE THEORY AND PRACTICE OF SILVICULTURE.

By Frederick S. Baker. McGraw-Hill Book Co., New York. \$5.00. 9 x 5 $\frac{1}{2}$; xiv + 502; 1934.

A textbook of forestry has to take account of the fact that forestry is as much a branch of economics as a field of applied biology and that in addition to this limitation, which all branches of applied science share, it calls for expert long-range fore-

casting of the results of a treatment that will be ended 50 or 100 years later. This book seems to be admirably well adapted to the nature of the subject and to be pedagogically sound. The plan is to survey the basic fields of knowledge upon which foresters may draw, including plant physiology and forest ecology, to indicate what practices are desirable from a theoretical standpoint and which are economically feasible, and to discuss silvicultural practices in the different forest regions of the United States. There is an extensive bibliography and an excellent index.



IDENTIFICATION OF THE COMMERCIAL TIMBERS OF THE UNITED STATES.

By H. P. Brown and A. J. Panshin.
McGraw-Hill Book Co., New York. \$3.00.
9 x 5½; xxvi + 223; 1934.

This book, the first of a new series of forestry textbooks, has two analytical keys for the identification of wood, one based on characters seen with the naked eye or with the aid of a hand lens, and the other based on anatomical characters visible in prepared sections under a compound microscope. Each key is illustrated by a set of excellent photomicrographs, about 270 in all, of transverse and tangential sections taken at magnifications of 5x or of 75x. One section is devoted to descriptions of the visible characters and anatomical structure of the woods of 90 species. In an introductory chapter there is a brief introduction to wood anatomy intended for people without previous botanical training, and the book closes with a glossary and a good index.



DIE TYPENLEHRE IN DER MIKROBIOLOGIE. Ihre Grundlagen und ihre Bedeutung für die Epidemiologie, Klinik und Therapie.

By Max Gundel. Gustav Fischer, Jena.
8 marks (paper); 9 marks (cloth). 9½ x 6½; viii + 192; 1934.

This book was written with a two-fold purpose, to indicate to the clinician the current status of knowledge of the groups of bacteria of presumably sub-specific rank

which have such different degrees of pathogenicity as to merit special consideration, and, for the benefit of bacteriologists and immunologists, to summarize the work that has been done on the discrimination of bacterial races and types by cultural and biochemical methods. Only bacteria pathogenic to man are discussed and the list includes most of the major groups of pathogens. There is an author index and a bibliography of nearly 350 titles.



DIAMETRAL CHANGES IN TREE TRUNKS. Carnegie Institution of Washington Publication No. 450.

By Ferdinand W. Haasis. Carnegie Institution of Washington, D.C. \$1.50 (paper); \$2.00 (cloth). 10 x 6½; 103; 1934.

On dry days the shrinkage in diameter of the trunk of North American forest trees may amount to 1/500 or even 1/100 of the diameter of the tree; when an adequate water supply is again available swelling takes place quickly. Besides dry weather several other factors can cause shrinkage, among them the development of new foliage and wounding. Haasis has classified the dendrographic records obtained at the Desert and Coastal Laboratories of the Carnegie Institution, where most of this kind of work has been done, and has summarized the results of other workers. His book is too over-burdened with details to make for easy reading, but it is a good summary of the present status of the subject, and there is an extensive bibliography.



FIELD STUDIES IN ECOLOGY.

By R. Bracher. J. W. Arrowsmith, London. 2s. 6d. 7½ x 4½; 100; 1934.

This little book is intended to lighten the task of college teachers organizing a course in ecology and it corresponds, roughly, to the laboratory manuals in use in other biological sciences. The principal plant communities of the British Isles are described briefly and there are short lists of the principal species to be found in each. The field methods a beginning class in

ecology can carry out are described in some detail and are illustrated by maps and diagrams. Although this was not written for our flora it ought to be a very useful book for American ecology teachers. There is a good index.



TREES OF THE SOUTHEASTERN STATES. Including *Virginia, North Carolina, South Carolina, Georgia and northern Florida.*

By William C. Coker and Henry R. Totten. University of North Carolina Press, Chapel Hill. \$2.00. $7\frac{1}{2} \times 4\frac{1}{2}$; vi + 399 + 3 plates; 1934.

An extremely useful work for all those, whether layman or student, who are interested in the native forests, naturalized trees and large shrubs of our southeastern states. The descriptions are in simple terms; the keys will not be difficult for the inexperienced to understand; typical leaves, flowers and fruits are illustrated of nearly all the species described; and, in many cases suggestions are made as to the desirability of the trees for use in ornamental planting. A bibliography, a glossary and an index are included in the volume.



THE PLANKTON ALGAE OF THE WEST END OF LAKE ERIE.

By Lewis H. Tiffany. Ohio State University Press, Columbus. $9\frac{1}{2} \times 6\frac{1}{2}$; 112; 1934 (paper).

This is a list, with descriptions, of the plankton algae found along the western shore of Lake Erie and in bodies of water on numerous islands in the west end of the lake. It includes some species not previously described elsewhere. A bibliography, an index and 15 plates picturing 364 varieties add to the usefulness of this contribution.



COMMENTATIONES FORESTALES 6. Die Technischen Eigenschaften der Birke Lettlands.

By Rob. Liepinš. Society of Forestry in Suomi, Helsingfors, Finland. $9\frac{1}{2} \times 6\frac{1}{2}$; 15; (1933).

ACTA FORESTALIA FENNICA 40. Suomen Messärieteollisen Seuran 25-Vuotis-Juhlajul-

kaisu (Special Issue on the Occasion of the 25 Years' Jubilee of the Society of Forestry in Suomi).

Society of Forestry in Suomi, Helsingfors, Finland. $9\frac{1}{2} \times 6\frac{1}{2}$; x + 901; 1934 (paper).



MORPHOLOGY

THE AUTONOMIC NERVOUS SYSTEM. Second Edition, Enlarged and Thoroughly Revised.

By Albert Kuntz. Lea and Febiger, Philadelphia. \$7.50. $9\frac{1}{2} \times 5\frac{1}{2}$; 697; 1934.

There is little to add to our notice of the first edition (Vol. 5, p. 251) except that the subject matter has been brought up-to-date. The chapters have the same titles but considerable internal change is evident.

"The new findings bearing on certain phases of the functional activity of the autonomic system have called for a critical reexamination of many generally accepted concepts which, in some instances, has resulted in a changed point of view, and, we trust, a better understanding. In the preparation of the second edition, the text has been revised in the light of the more recent studies and an attempt has been made as far as possible, to incorporate all the more important findings, without materially increasing the size of the volume."



DEVELOPMENTAL ANATOMY. A Text-book and Laboratory Manual of Embryology.

By L. B. Arty. W. B. Saunders Co., Philadelphia. \$6.50. $9\frac{1}{2} \times 6\frac{1}{2}$; ix + 593; 1934.

This standard American textbook for students of human embryology has been revised, in its third edition, by rewriting much of the text matter, adding 181 new illustrations, and bringing the discussions into line with latest findings. The book is so well known to anatomists, zoologists and medical students that further discourse here would seem superfluous.



A TEXTBOOK OF HISTOLOGY. Second Edition, Completely Revised.

By Alexander A. Maximow and William Bloom. W. B. Saunders Co., Philadelphia. \$7.00 net. $9\frac{1}{2} \times 6\frac{1}{2}$; xiv + 662; 1934.

The first edition of this text was noticed

in these columns (Vol. 6, p. 242). The book has now been recast by the original editor and made smaller and more useable for beginning students of medicine. The section on the nervous tissue was again written by Prof. C. J. Herrick. The book is to be recommended.



PHYSIOLOGY AND PATHOLOGY

PAPERS OF CHARLES V. CHAPIN, M.D. *A Review of Public Health Realities.*

Selected by Frederic P. Gorham. Edited by Clarence L. Scamman. The Commonwealth Fund, New York. \$1.50. 8½ x 5½; xxiv + 244; 1934.

In this book sixteen of Dr. Chapin's most important papers in the field of public health are reprinted. The first six papers, under the heading of public health administration, relate "to the dangers of indiscriminate and hasty publication, to the wise expenditure of public funds, and to the assimilation and use of new scientific knowledge and technique." A second group of five papers, on the control of communicable disease, are representative of scientifically sound and thoroughly practical views on the importance of aseptic nursing, hospital isolation, the identification of carriers, the reporting and recording of cases, the importance of personal cleanliness which are today the essence of protection against communicable disease. The last group of five papers, under the title epidemiology and vital statistics, are typical of Dr. Chapin's contributions in the field of quantitative methodology. In addition to the reprints, the volume contains a well written foreword which may be expected to stimulate in the most casual reader an interest in public health work, a short biographical sketch, and a complete bibliography of the books and articles (133 references) by Dr. Chapin. High commendation should be extended to the persons responsible for the republication of these scattered and not easily available papers. The book profitably can be read by every person truly interested in public health work. It is a particularly appropriate title to be in-

cluded in the collateral reading list of medical students today.



CELLULAR RESPIRATION.

By Norman U. Meldrum. Methuen and Co., London. 3s. 6d. net. 6¼ x 4¼; xi + 116; 1934.

A young investigator at Cambridge University, who did not live to see the publication of his book, has written an extraordinarily clear, brief exposition of the present status of our knowledge of intracellular oxidations and reductions that ought to be of uncommon usefulness to any student of the subject. His temper is critical, but it is not the sort of criticism that leads to the impression that the research in question would have been better done if the author had done it; it is rather the careful sorting out of certain relevant facts from a highly specialized field of research to form a plausible physiological system. It is written for graduate students in physiology. It is provided with a better glossary than could have been expected, a good index, and with short bibliographies at the end of each chapter.



LA CELLULE GERMINALE DANS LE DYNAMISME DE L'ONTOGENÈSE. *Actualités Scientifiques et Industrielles 119. Exposés de Biologie, La Cellule Germinale dans l'Ontogenèse et l'Évolution, I.*

By Vera Dantchakoff. Hermann et Cie, Paris. 18 francs. 10 x 6½; 87; 1934 (paper).

A series of well conceived experiments regarding the development of germ cells and its relation to that of the gonads are here reported. The author has proceeded to a localized destruction of embryonic tissue (of bird embryos mostly) and of the germ cells by x-rays. As a consequence she observed that in the absence of germ cells the gonads are not formed nor the metanephros differentiated. The primordial germ cells, she concludes, are an important factor in morphogenesis of the developing organs. There is an excellent critical review of the literature and the author has succeeded in presenting her

results as a logical sequence of the work of others.



PARASITISM AND DISEASE.

By Theobald Smith. Princeton University Press, Princeton, N. J. \$2.00. 8½ x 5½; xiii + 196; 1934.

The relationship between disease and parasitism in its broadest aspects, incorporating the author's unpublished Lowell lectures for 1909 and Herter lectures for 1916, reach final publication in these, the Vanuxem lectures. Bringing to bear upon the problem a wealth of research experience and an intimate personal acquaintance with modern developments Dr. Smith (whose lamented death is an irreplaceable loss to American science) here puts together, as a unified whole, all that is known of the struggle of man and the higher animals against infectious and invasive diseases.



ESSAI DE CLASSIFICATION DES SUBSTANCES SYMPATHICOMIMÉTIQUES. *Actualités Scientifiques et Industrielles*, 135. *Exposés de Physiologie*, III.

By Z. M. Bacq. Hermann et Cie, Paris. 8 francs. 10 x 6½; 24; 1934 (paper).

The author classifies what he calls sympathomimetic substances into perfect and imperfect. His criterion for differentiation is that the former through their intimate physico-chemical and physiologic properties simulate perfectly the functions of the sympathetic system while the latter instead only partially simulate them and then only through physico-chemical excitations of the post-ganglionic fibres. In the first group he places adrenaline and sympathin, in the second, ephedrin, tyramine, and amylamine.



ASSOCIATIONS FONCTIONNELLES et Milieu Intérieur. *Actualités Scientifiques et Industrielles*, 155. *Leçons de Zoologie et Biologie Générale*, V.

By Georges Bohn. Hermann et Cie, Paris. 15 francs. 10 x 6½; 89; 1934 (paper).

In this volume of his *Leçons* the eminent author presents an outline of the present knowledge regarding polarity, regeneration and tropisms; development of the bony skeleton; properties and composition of the blood and hormones; development of the central nervous system, muscular contraction; the functions of the urogenital system. Well written, with emphasis only on what has definitely been proven, this book should be useful to students of biology.



HYGIENE FOR FRESHMEN.

By Alfred Worcester. Charles C Thomas, Springfield. \$1.50. 8½ x 5½; vii + 151; 1934.

This book gives the substance of a half-year weekly lecture course in Hygiene given to Harvard freshmen. Nine lectures are devoted to very elementary considerations of general biology and human physiology, three deal with mental hygiene, disease prevention and immunity. Questions at the end of each chapter indicate what the author hopes the student will remember. There is a two page glossary and an index.



LA CELLULE VIVANTE. *Physiologie et Pathologie Cellulaires*.

By E. M. Poletti. Translated by Gaullieur l'Hardy. Gaston Doin et Cie, Paris. 25 francs. 9½ x 6½; ii + 133; 1934 (paper).

A very interesting presentation of facts and theories regarding cellular physiology and pathology. The author manifests uncommon erudition and his exposition is succinct and justly critical. The lack of a bibliography is to be deplored.



THE LANGHAN'S CELLULE ABERRATED IS THE SPECIFIC CELLULE OF CANCER. *The Matrix Embryonic Cellule of the Primal Syncytium, the Langhan's Cellule; Its Great Importance Throughout Life; Especially in the Early Days of Ovum Life. The Copenhagen Theory. The Cellulettes. Syncytioma. The Pre-Cancerous Carcinoids. Teratomata. An*

Illustrated Review of Some Primal Embryology, 2-8th Week, Including the Normal and Abnormal Cancer Cells.

By Frank A. Stahl. Frank A. Stahl, Hamilton Club, Chicago. Free. 9½ x 6; 154; 1934 (paper).



BIOCHEMISTRY

MEDIZINISCHE KOLLOIDLEHRE. *Lieferungen* 12, 13 und 14 (Schlusslieferung).

Edited by L. Lichtwitz, Raph. Ed. Liesegang and Karl Spiro. Theodor Steinkopff, Dresden. 5 marks each. 10½ x 7½; pp. 849-1084; 1934 (paper).

These three numbers complete an excellent work on colloid chemistry and its application to medicine. The earlier numbers have been noticed in these columns at various times. The subjects treated in the present *Lieferungen* are: Relations between pharmacology and colloid theory, by E. Starkenstein; Radiation therapy, by R. E. Liesegang; Bandage materials, by Hans Moser; The Wasserman and gold reactions from the standpoint of colloid chemistry, by Carl Lange; Tests for kidney functioning, by F. Hermann; Methods of histological technique from the standpoint of colloid chemistry, by K. Zeiger; Internal medicine, by L. Lichtwitz; Colloid chemistry and surgery, by C. Häbler; and Gynecology and obstetrics, by J. Voigt. The last number is equipped with author and subject indices for the complete series.



LANE MEDICAL LECTURES: BIOCHEMICAL STUDIES OF NUTRITIONAL PROBLEMS.

By J. C. Drummond. Stanford University Press, Stanford University. \$1.00 (paper) \$1.50 (cloth). 10 x 6½; 106; 1934.

A series of lectures given at Stanford University. The author is Professor of Biochemistry and Dean of the Faculty of Medical Science at the University of London, and an outstanding figure in the study of nutrition. The titles of the five lectures are as follows: The character of modern problems of nutrition, the "protein factor" in nutrition, the nutritional value of fats, the fat-soluble vitamins in

nutrition, the water-soluble vitamins in nutrition. Tables and figures are included in the text, references to literature are given, and at the end of the publication is an index.



BIOCHIMIE DE LA CONTRACTION MUSCULAIRE. *Actualités Scientifiques et Industrielles* 113. *Exposés de Physiologie*, II.

By Théophile Cahn and Jacques Houget. Hermann et Cie, Paris. 12 francs. 10 x 6½; 43; 1934 (paper).

The chemical changes that take place on contraction of striated muscles as observed from analysis of muscle extracts, experiments on muscles, isolated and *in vivo*, etc. are here briefly but adequately summarized. Due credit is given to the several investigators but exact references and bibliography have been omitted.



HORMONES ET VITAMINES. *Un aspect du problème des quantités infinitésimales en biologie. Actualités Scientifiques et Industrielles*, 136. *Exposés de Biologie Générale en Rapport avec la Cytologie*, II.

By Z. M. Bacq. Hermann et Cie, Paris. 8 francs. 10 x 6½; 29; 1934 (paper).

A review of the chemical properties and physiologic actions of those hormones and vitamins which have been more extensively and securely identified. There is an excellent bibliography.



SEX

SEX AND CULTURE

By J. D. Unwin. Oxford University Press, London. \$12.00. 9½ x 6½; xxiii + 676; 1934.

Moved by a desire to test the applicability of the psychological theory of sublimation to social groups, Dr. Unwin examines in a scholarly manner, in great detail and with an astounding wealth of evidence the sexual taboos and religious culture of some 80 uncivilized peoples. Correlation between the number and severity of taboos and the religious culture leads him to conclude (p. 300):

1. All the zoistic societies permitted pre-nuptial sexual freedom; conversely, all the societies which permitted that freedom were in the zoistic condition.

2. All the manistic societies had adopted such regulations as compelled an irregular or occasional continence; conversely, all the societies which had adopted such regulations were in the manistic condition.

3. All the deistic societies insisted on pre-nuptial chastity; conversely, all the societies which insisted on pre-nuptial chastity were in the deistic condition.

The author denies that this simply means that greater formal restrictions accompany higher cultural states but insists instead (p. 302) "If, therefore, there is any causal relationship between a reduction of sexual opportunity and cultural condition, the continence must have caused the thought which produced the change in ideas, and so the cultural change. The contrary cannot have been the case." He adds (p. 326) that the full effect of extension or limitation of continence is reached in a hundred years.

The author goes on to argue that his conclusions and derived laws are verified in the rise and fall of the Sumerians, the Babylonians, Greeks, Romans, Anglo-Saxons, and English, the history of which peoples he sketches very briefly. Needless to say it appears true in each instance. And the author, with evident faith in the power of mind over matter ventures to summarize and advise (p. 432):

If... a vigorous society wishes to display its productive energy for a long time, and even forever, it must re-create itself, I think, first, by placing the sexes on a level of complete legal equality, and then by altering its economic and social organization in such a way as to render it both possible and tolerable for sexual opportunity to remain at a minimum for an extended period, and even forever. In such a case the face of the society would be set in the Direction of the Cultural Process; its inherited tradition would be continually enriched; it would achieve a higher culture than has yet been attained; by the action of human entropy its tradition would be augmented and refined in a manner which surpasses our present understanding.



THREE ESSAYS ON SEX AND MARRIAGE.

By Edward Westermarck. *The Macmillan Co., New York.* \$6.00. 8½ x 5½; ix + 353; 1934.

In the first of these essays the distinguished author of *The History of Human Marriage* criticizes the work of Freud and

his followers on the Oedipus complex. The psychoanalytic method, he concludes, is liable to lead to errors, first because memory, as has been shown by Stern and others, is far from infallible, and second because the leading questions of the analyst are likely to distort the facts still farther. Freud interprets such customs as totemism, exogamy and the killing of the divine king as reminiscences of the primeval crime by which the sons killed and ate their father in revenge for his preventing them from enjoying the women of the family and then, filled with remorse, passed a self-denying ordinance renouncing intercourse with their mothers and sisters. These customs, however, Westermarck concludes, are susceptible of more satisfactory interpretations.

The second essay deals with the recent theories of exogamy of Briffault, Mrs. Seligman, Malinowski and Lord Raglan. Westermarck himself derives the incest prohibition from the "absence of erotic feelings between persons living very closely together from childhood."

The third essay is a rejoinder to Briffault's *The Mothers*. Briffault, as Havelock Ellis remarks, "might seem to belong to that class of controversialists who hold that we should reply not to what our adversary actually said, but to what he ought to have said if we are to triumph over him." Much of the essay is therefore devoted to a correction of Briffault's misquotations of Westermarck and of the authorities whom he had cited. The remainder deals with fresh material which has appeared since the latest edition of *The History of Human Marriage*. This confirms Westermarck in his conclusions that more or less permanent sexual partnerships are found among various species of mammals, including the anthropoid apes, that the unit of organization of primitive man was probably the family consisting of father, mother and children, rather than the promiscuous herd, as Briffault contends, that premarital intercourse is condemned in about half of the uncivilized peoples about whom there is information, that the evolution of marriage is from monogamy to polygamy and back again to monogamy and that polyandry, the lending of wives to guests and other customs which Briff-

fault regards as derived from the primitive group marriage which he postulates cannot be so interpreted. When one considers the wide variation in the customs of different peoples and the variety of unknown factors that may have influenced their evolution it seems to at least one reader that any conclusions as to the origin of the family or of exogamy can at best be no more than probable.



HUMAN STERILITY. *Causation, Diagnosis, and Treatment. A Practical Manual of Clinical Procedure.*

By Samuel R. Meaker. *The Williams & Wilkins Co., Baltimore.* \$4.00. 9 x 6; xv + 276; 1934.

The author points out that the "time has not yet come for an exhaustive treatise on human sterility, since many details of the problem remain imperfectly understood. . . . Nevertheless, within the last twenty years, significant progress has been made, particularly in the clinical management of involuntary sterility. Doctor Meaker is a pioneer in this field and his book with its clear discussion of the many phases of the diagnosis and treatment of sterility and its extensive clinical records will be of valuable assistance to those of the medical profession who have such cases to deal with. It also lays the foundation for future work along this line. The three main sections of the volume are: Causation of human sterility, diagnostic study of the sterile mating, and treatment of sterility. Figures and tables occur in the text. There is a bibliography of 66 titles and an index. A brief foreword is contributed by Doctors G. W. Kosmak and R. L. Dickinson.



CONCEPTION PERIOD OF WOMEN.

By Kyusaku Ogino. *English translation by Yonez Miyagawa. Medical Arts Publishing Co., Harrisburg, Pa.* \$2.00. 7½ x 5; 95; 1934.

This little volume on the so-called "safe period" is one of the numerous tracts published recently upon the subject. It cannot be classed as propaganda, though it

can be used as a strong argument by those who advocate the "natural" method of birth control. The figures given by Ogino happen to agree with those of Knaus; hence the O.K. (Ogino Knaus) theory. Knaus claims that ovulation occurs 14 days, and Ogino 11 days, before the onset of the succeeding menstrual flow. Ogino arrived at his conclusion through inspection of ovaries at laparotomy, by no means a new method; and he records the experiences of his patients with the safe period. When his method is correctly used the results are alleged to be 100 percent successful, though whether a patient's statements can be classed as complete evidence is open to question.



THE POWER TO LOVE. *A Psychic and Physiologic Study of Regeneration.*

By Edwin W. Hirsch. Alfred A. Knopf, New York. \$4.00. 8½ x 5½; xxi + 363 + ix; 1934.

Notwithstanding its title this book is a good popular presentation of the causes and therapy of male sexual incompetency. With some foundation, the author expresses the opinion that not enough attention has been given to the psychogenic factors and this is the reason for the doubtful results derived from medical and surgical intervention. He therefore gives in minute details the technique of coition which he considers most efficacious in attempting to overcome psychic impotence. A book that can well be recommended to men young and inexperienced in sexual matters.



GESCHLECHTSENTSTEHUNG UND WILLKÜRLICHE GESCHLECHTSBESTIMMUNG.

By E. Kramer. *Deutsches Verlagshaus Bong und Co., Berlin and Leipzig.* 3.50 marks. 9½ x 6½; 40; 1934 (paper).

After disposing of all previous beliefs about the controlling of sex as erroneous, the author gives a detailed discussion of the chromosome theory of sex determination upon which his particular pet theory is based. Since there is a deviation from the expected 50:50 sex-ratio in all verte-

brates studied, the author says there must be a modifying factor and believes that it can be traced to the differential pH toleration of the x and y sperms. Alkalization of the vaginal tract in 74 normal women resulted in all cases in male births. Attempts to produce females have not been successful.



THE NEW ART OF LOVE. *A Practical Guide for the Married and Those About to Marry.*

By George R. Scott. John Bale, Sons and Danielsson, London. 3s. 6d. net. 7½ x 4½; 117; 1934.

The title is somewhat misleading, as nothing new or original is said about the art of love. But the discussion of the subject is sound, scientific, and free from floweriness or sentimentality. Concerning any disputed point the author cites references, and endeavors to give in every case the most up-to-date information. There is an index.



BIOMETRY

PROFILO DI UNA STATISTICA BIOLOGICA.

By Alfredo Niceforo. *Difesa Sociale*, Rome. 8½ x 6½; 316; 1933 (paper).

In this volume which appeared serially in *Difesa Sociale*, 1932, 1933, and 1934, Professor Niceforo continues to develop and extend his views on the application of statistical method to different biological problems. Acutely critical, he surveys and reports his own and the investigations of many others as illustrations of the value of statistical treatment which shorn of much of its forbidding mathematical form becomes an elegant means of analysis. With emphasis on the diverse technical approach to the various problems the author considers at length applications to medicine, botany, zoology, anthropology, psychology, genetics, biosociology, and concludes with an excellent exposition of elementary statistical method.

Professor Niceforo's style of writing and profound culture render this book thought provoking both for statistician

and layman. For the former because it presents instances of unusual applications, for the latter because it expresses with unusual clarity the object of statistics.



KÖRPERFORM UND SPORTLICHE LEISTUNG JUGENDLICHER KÖRPERMASSE, *Sportliche Leistungen und deren korrelative Abhängigkeit bei 3319 Schülern Münchener höherer Lehranstalten.*

By Emil Breitinger. Emil Breitinger, Linprunstrasse 65, München. RM. 3. 9½ x 6½; 110; 1933 (paper).

Measurements obtained in 1930-31 from approximately 3000 school boys 10 to 20 years of age furnish data for the calculation of means, variability constants, and intercorrelations of anthropometric characteristics (height, weight, height-weight index; trunk, leg and arm lengths; shoulder and pelvic breadths; and chest circumference) and tests of athletic ability (60 meter sprint, standing and running jumps and throwing ability). Attention is directed primarily to the correlations of body form and athletic ability, which, generally, are low except during the adolescent period. The book is a valuable source of data. There is an extensive bibliography.



SANKHYĀ. *The Indian Journal of Statistics. Vol. 1, Part 1.*

Edited by P. C. Mahalanobis. Art Press, Calcutta. 9 shillings net. 11½ x 8½; 154; 1933 (paper).

The title of this journal, published under the auspices of the recently founded Indian Statistical Institute, is a Sanskrit word meaning "determinate knowledge." The editor contributes three papers to the first number: The reliability of a group-test of intelligence in Bengali; Revision of Risley's anthropometric data relating to tribes and castes of Bengal; Tables for the application of L-tests. Other papers deal with Indian prices during the depression, Galton's work on the evidential value of finger prints, and maternity statistics from Mysore.

THE METHODS OF STATISTICS. *An Introduction Mainly for Workers in the Biological Sciences.*

By L. H. C. Tippett. Williams and Norgate, London. 15 shillings net. 8½ x 5½; 222; 1931.

This book presents both the classical biometric methods developed by Karl Pearson and his school and the newer methods, centering about the analysis of variance, due largely to R. A. Fisher. Mathematical proofs are given where they are easy, but when they are not the results only are stated. A bibliography of three pages and an index are provided.



TABLES OF THE HIGHER MATHEMATICAL FUNCTIONS. *Volume I.*

Computed and Compiled under the Direction of Harold T. Davis, with the co-operation of Muriel E. Adams, Catherine Bennett, James A. Cooley, Frank K. Edmondson, Edward E. Edwards, Edwin L. Godfrey, H. E. H. Greenleaf, Mabel E. Inco, Lucy C. Kantz, William J. Kirkham, Voris V. Latschaw, Anna M. Lescisin, Lloyd G. Mitton, Edward B. Morris, Paul W. Overman, Irene Price, Marion B. Shelly, Dorothy J. Stephan, John R. Wetnight, Kathryn E. Withers. The Principia Press, Bloomington, Indiana. \$6.50. 9¾ x 6¾; xiii + 377; 1933.

This excellent book contains a short history of mathematical tables with reproductions of pages from the 1538 edition of Ptolemy's *Almagest* and the first edition of Napier's *Descriptio*, a bibliography, interpolation formulae with auxiliary tables, and discussion and tables of the gamma and psi functions. Name and subject indexes are provided.



PSYCHOLOGY AND BEHAVIOR

A HANDBOOK OF GENERAL EXPERIMENTAL PSYCHOLOGY.

Edited by Carl Murchison. Clark University Press, Worcester. \$6.00. 9 x 5½; xii + 1125; 1934.

This is the second volume of what may be

called the revised edition of *The Foundations of Experimental Psychology*. With but few exceptions all the chapters have been augmented by the results of the most recent observations. The book is divided into two parts. The first on Adjustive Processes contains articles by W. J. Crozier, T. H. Morgan, A. Forbes, J. G. Dusser de Barenne, W. B. Cannon, P. Bard, C. Landis, C. P. Stone, C. L. Hull, K. S. Lashley, W. S. Hunter and E. S. Robinson. The second part treats of Receptive Processes with papers by L. T. Troland, S. Hecht, C. H. Graham, H. Banister, H. Hartridge, H. Davis, W. J. Crozier and J. P. Nafe. Aside from the eminence of the authors, it can be said that most of the articles are well written and comprehensive from the standpoint of literature and from that of description and interpretation of observations. A useful reference book.



COMPARATIVE PSYCHOLOGY.

By Edward L. Thorndike, R. H. Waters, Calvin P. Stone, F. A. Moss, Donald M. Purdy, Paul E. Fields, Shepherd I. Franz, Howard S. Liddell, W. T. Heron, Edward C. Tolman, Robert C. Tryon, Otto L. Tinklepaugh. Edited by F. A. Moss. Prentice-Hall, New York. \$3.50. 8 x 5½; xiii + 529; 1934.

This book is a coöperative one which was planned at the Cornell meeting of the American Psychological Association. Each contributor develops his assigned topic as he sees fit, taking all responsibility for it.

Thorndike's introductory chapter on "Why study animal psychology?" is all too short. The second chapter on historical background is also concise but interesting and readable. The rest of the book is technical. In the chapter on individual differences the statements in regard to inbreeding of animal stocks seem curious to a biologist. That inbreeding may differ in intensity or amount is apparently not considered, but according to this author "inbred stock" should not be used to study individual differences because the individual animals will be too much alike!

DEVELOPMENTAL PSYCHOLOGY. *An Introduction to the Study of Human Behavior.*

By Florence L. Goodenough. D. Appleton-Century Co., New York. \$3.00. 7½ x 5½; xvii + 619; 1934.

This excellent textbook deals with the development of behavior from the prenatal period to old age. Among the topics considered are the hereditary background, the prenatal growth of the nervous system, the sense organs, emotional and social behavior in the various periods of growth, intelligence tests, educational and vocational guidance, the maturation and decline of abilities, and mental disease. A bibliography in the form of footnotes and author and subject indexes are given.



SÉMIOLOGIE DU SOMMEIL: *Essai de Neurologie Expliquée.*

By Auguste Tournay. G. Doin et Cie, Paris. 30 francs. 9½ x 6½; 131; 1934 (paper).

The chief merit of this book is that it brings together neurological approaches to the explanation of normal sleep and its symptoms as differentiated from similar states. The experiments of the author, principally on the tendinous and cutaneous reflex actions, some of which become pathological during sleep, are incorporated. He, however, treats them in as critical a manner as the work of others, and no claim is made of a complete solution of the problem. There is a lengthy

bibliography, and indices of authors and subjects.



DE OMNIBUS REBUS ET QUIBUSDEM ALIIS

MIND AND NATURE.

By Hermann Weyl. University of Pennsylvania Press, Philadelphia. \$1.50. 8 x 5½; vii + 100; 1934.

These lectures, delivered on the William J. Cooper Foundation at Swarthmore College, deal with some of the philosophical implications of modern physics. As early as Galileo it was recognized that colors and sounds, tastes and odors, were sensations, not properties of objects existing independently of the perceiver, and these secondary qualities were contrasted with primary qualities such as extension and motion which were supposed to exist in the objects themselves. Modern developments in physics have shown that this distinction is not tenable, that space and time are different for different observers. Physics "constructs an objective world in mathematical symbols, but afterwards, to establish the connection with experience, it has to indicate by what procedure the quantities are found which are decisive for immediate perception—decisive in such a way, that equal values of these quantities indicate equal perceptions. In doing that it must of course include the observer as a physical being and his condition in the objective world."



THE QUARTERLY REVIEW of BIOLOGY

BIOLOGICAL AND MEDICAL RESEARCH AT THE BUREAU OF SCIENCE, MANILA

By PAUL F. RUSSELL, M.D.

Field Director of the International Health Division of The Rockefeller Foundation, assigned to the Bureau of Science, Manila, as Chief of Malaria Investigations

(The studies and observations on which this paper is based were conducted with the support and under the auspices of the International Health Division of The Rockefeller Foundation. The manuscript of the paper was completed early in 1933.)

HISTORY

WHEN Americans occupied the Philippine Islands, laboratory facilities in the field of medicine were practically non-existent. Such as had existed in Spanish times, chiefly for chemical analyses, were reorganized into a "Municipal Laboratory of Manila" in charge of W. J. Calvert, who returned to the United States in 1901.

The genesis of the Bureau of Science should rightfully be placed in the organization by the United States Army in 1899 of the (first) Board for the Investigation of Tropical Diseases in the Philippine Islands. Richard P. Strong was appointed president of this Board by the Secretary of War. Strong proceeded at once to organize an Army Pathological Laboratory which, from 1899 until the Government Laboratories were established in 1901, did practically all of the medical diagnostic

work for hospitals and physicians in and about Manila. Strong was well equipped for this work and did much to establish medical diagnosis on a rational basis. Prior to his work the situation was chaotic.

When Drs. Simon Flexner, L. F. Barker, Joseph M. Flint, and Frederick P. Gay, of the Johns Hopkins Commission for the Study of Tropical Pathology arrived in Manila, in the summer of 1899, they were invited to work in this laboratory. The invitation was accepted during their stay of two months in the Islands. Barker and Flint studied such clinical problems as the differential diagnosis of malaria and typhoid fever, working especially in the wards, among American soldiers. They also studied beriberi, going to Cavite to work among prisoners.

Flexner and Gay studied intestinal infections, especially bacillary dysentery. It was at this time that Flexner isolated the *Bacillus dysenteriae*. He found it in

three fatal cases of dysentery and also in some non-fatal cases, by rectal cultures. This was the first confirmation of Shiga's discovery. Along with other strains of *Bacillus dysenteriae*, Strong isolated a strain which Lentz subsequently placed in a separate group, because of its fermentation and its serum reactions. Probably the first serum ever manufactured and used in the treatment of bacillary dysentery was made and used in this laboratory. *Micrococcus melitensis* was also first isolated in Manila in this laboratory and redescribed from a fatal case of undulant fever. The pathological histology and the rôle of *Balantidium coli* infection was also first demonstrated there, and an extensive study of the etiology of the dysenteries in Manila was prosecuted by Strong and Musgrave.

The Government Laboratories of the Philippine Civil Commission were established at 781 Calle Iris in October 1901. Dr. Paul C. Freer was appointed superintendent and in his first report we note that from the very outset the routine work of these general laboratories included diagnostic analyses of specimens from hospitals, from the board of health, and from municipal physicians, with bacteriological examinations, dissection of plague-suspected rats and other similar procedures. A serum institute was a part of the original organization. Doctor Freer in his first report stressed the need and the value of medical research in the Philippines. Strong was appointed first director of the biological laboratory, returning from leave to this position on January 1, 1902. The work of the Army Pathological Laboratory was largely transferred to the Government Laboratories.

In October 1902 the present buildings on Calle Herran were begun and they were occupied in September 1904. In 1902 Miss Mary Polk was appointed librarian,

and the Bureau of Science library began its amazing growth which has continued until the present time, when it is recognized to be the best scientific library in the Orient, east of Suez. On December 31, 1932, there were in the library 76,498 bound volumes, 60,610 unbound volumes, and 2,622 current periodicals.

As early as 1904 Doctor Freer stated that the Government Laboratories welcomed scientific investigators from other countries and this policy of international coöperation has been continued.

Tropical medicine was an important part of the Laboratory's problems. Quoting from Doctor Freer's third annual report,

interest in tropical medicine has developed markedly of recent years, and it must be understood that not only has this branch of scientific work taught us to understand the Tropics to as great an extent as has any other field, but it has reacted beneficially upon medical knowledge in temperate climates, and much has been learned from the facts gained near the equator which has been of advantage in the practice of medicine at home.

Strong, during his thirteen years in the Islands, had much to do with the development of the biological laboratories.

On November 1, 1905, the title of Government Laboratories was changed to "The Bureau of Science," a name soon made famous throughout the world because of the high quality of its studies in many fields of tropical science. Not the least important phase of its activities was and has always been medical. For example, there are the interesting facts that the Director of the Bureau of Science was made Dean of the Philippine Medical School in December 1906 and that six members of the staff of the Bureau were actively teaching in the School after its opening in June 1907, with fifty-four pupils. The laboratory studies of the students were done almost entirely in the

Bureau. In fact, quoting Director-Dean Freer, relations between the bureau and the school were "so inseparable that one can scarcely be considered without the other."

In 1908 the Bureau of Science had a large part in the formation, at the meetings of the Philippine Islands Medical Association, of the Far Eastern Association of Tropical Medicine, and the proceedings of the first meetings of the new organization, held in Manila in 1910, were published in the *Philippine Journal of Science*. The *Journal* had appeared under the auspices of the Bureau of Science in January 1906 and has been published consecutively ever since, building for itself a name known throughout the world for the excellence of its articles. Much of the material appearing in the pages of this journal has been submitted by members of the staff of the Bureau. That this staff was making an unusual reputation for itself in the field of medical research may be gathered from the statement of that great German parasitologist, Professor Fülleborn of the Hamburg School of Tropical Medicine. He stated that the Bureau of Science laboratories furnished better opportunity for the study of tropical medicine than any other institution with which he was familiar.

One of the main reasons why the opportunities have been so great has been the fact that all phases of research in tropical science have been housed in one group of buildings under one director. The utmost in coördination has been possible. No one can deny the close interrelationship of medical research and other branches of tropical science, especially in such divisions as chemistry, entomology, anthropology, and botany, and not excluding ornithology and fisheries. The whole field of tropical science is bound together, and no one can separate

it rigidly into independent divisions. In this respect what a unique institution the Bureau of Science has been! Biologists and chemists working side by side; ornithologists, entomologists, ichthyologists, and anthropologists together under the coördinating influence of a single bureau, directed by men of broad scientific vision.

The Bureau of Science has never shirked routine work. No less than four and a quarter million routine examinations in the field of medicine and health alone have been made by the Divisions of Chemistry and Biology since 1905; and no fewer than 223 million units or ampules of vaccines and serums have been manufactured by the Bureau of Science in the same time. It is beyond the power of the human mind to visualize what this has meant in the life of the Philippine Islands. Hundreds of thousands of Filipinos have been spared the horrors of death by smallpox; millions have been protected from cholera, typhoid fever, and tetanus. The more than 622,000 bottles of tikitiki sold or given away have prevented beriberi in many thousands of Filipino children, and thousands have been saved from death by antirabies treatment.

The Bureau of Science safeguards public health in the Philippines to an extent far greater than is generally known. For example, quite apart from fundamental researches into the nature and control of local diseases, and in addition to basic analyses of such staple foodstuffs as rice and soy beans in relation to their vitamin content and nutritive values, the Bureau of Science examines routinely all sorts of foods submitted by various agencies such as the Bureaus of Health and Customs. These tests, to determine whether or not the provisions of the Food and Drugs Act are satisfied, include such foodstuffs as imported canned salmon, sardines, etc., local ice cream, coconut and other vege-

table oils, meats, lard, milk, soft drinks, alcoholic beverages, bread, confectionery, fruits, vegetables, fish, sugar, molasses, cheese, flour, and cereals. Soaps, dyes, drugs, and medicines are also tested to screen out those injurious to health and those which are mislabeled. Manila's food handlers are examined, as well as samples of water from all over the Archipelago. The strength of cement and other structural materials is measured from the standpoint of public safety.

A tremendous number of biological specimens are examined. Practical training is given yearly to thousands of Filipina housewives in the preparation of food. Demonstrations are made not only daily at the Bureau of Science but by traveling demonstrators in provincial towns.

Finally, the Bureau of Science conducts a consultation service which includes all phases of life in the Islands. Any citizen at any time may go to the Bureau for scientific information about any subject.

But it must not be forgotten that all this routine work in medicine rests on the firm foundation of medical research. Without investigation, the routine work could not exist. For example, it was only following intensive research that tikitiki was developed as a cure for infant beriberi. The experience at the Bureau has demonstrated that in a well coördinated scientific institution routine examination and scientific research can go on together, each benefiting by the other. In biological problems affecting human health, routine and investigative work are always closely associated.

We wish to pay tribute, in this consideration of the Bureau of Science, to Dean C. Worcester, who, as Secretary of the Interior of the Government of the Philippine Islands, drafted legislation which had for its object the placing of scientific work upon a firm and lasting

foundation. To Mr. Worcester more than to any other individual belongs the credit for the establishment of the Bureau of Government Laboratories which became the Bureau of Science. It was Worcester who had the vision, it was Worcester who had the energy to make real his dream. We wish also to pay our respects to Paul C. Freer, the first director, a thorough gentleman and a polyglot, a man of great scientific and business ability, through whose foresight, judgment, and perseverance, the Bureau was so successfully carried through its early years. Doctor Freer was not only an able chemist and administrator, but a capable, independent investigator whose observations on the effects of tropical sunlight were noteworthy. His successors have carried on in the same spirit of unselfish devotion to science, and although none has been primarily interested in medical science, yet each has lent his unstinted support to medical and biological research.

Numerous quotations could be given to indicate the esteem in which the Bureau was held locally and abroad. For example, the *Britannica Year Book* in 1913 described the Bureau of Science as "a great research institution that is now classed with the best in the world." Members of the staff of the Bureau were and are participating in scientific congresses all over the world. Many of those who have returned to the United States are occupying positions of prominence.

Former Governor General Cameron Forbes in 1928 wrote that the Bureau of Science

was probably the most important single institution in the Philippines, and for years it rendered vitally important service not only to the Philippine Government in its various departments but also to the world at large, through its scientific research work. It attained a position of great eminence and credit, but on account of the lack of adequate support and adequate personnel it does not occupy the position

today that it did from 1905 to 1915. Reorganization and the appointment of personnel adequate in all respects is imperative. The work of this institution is of inestimable value to the Philippines and to the world at large.

Although this paper is primarily concerned with medical research at the Bureau of Science, it would not be amiss to call further attention to the diversity of the Bureau's contributions to the general welfare of the people of the Philippine Islands.

A quotation from Victor G. Heiser, who was for many years director of the Philippine Health Service and who had a very active part in encouraging and aiding the growth of the Bureau of Science, will make clear how widespread have been the interests of this Bureau.

Referring directly to the Bureau of Science, Heiser wrote:

The number of uses to which these laboratories were put surprised even the most ardent supporters of the movement. Answers were available as to whether a curious mineral found was gold, whether a resin gathered in the jungle had commercial value, whether a food was adulterated or poisonous, or whether an illness was cholera or plague or leprosy or something harmless. The durability of road-making material could be tested, the possibilities of silk worm culture were worked out, the commercial value of many curious tropical products could be ascertained; in short, definite knowledge was to be had instead of surmises which so often are incorrect. If a photograph were needed, this bureau not only took it but filed it away so that it might be available in the years to come. A great scientific library was assembled, serving as a storehouse of knowledge not only for the Philippine Islands but for much of the East. Entirely new industries sometimes resulted from the researches. Great contributions to the world's knowledge were made. The scientific work was of the highest character. *The Journal of Science*, published by the Bureau, became a recognized source of authority in the principal countries.

In reviewing the history of the Bureau of Science it has not been easy to curb enthusiasm. One might gain the impression from this paper that the Bureau has

been a leader in every public health investigation in the Philippines. Therefore it may be well in passing to note that a great deal of important work has been done entirely outside the Bureau. For example, the Philippine Health Service under the notable leadership of Victor G. Heiser, and subsequently, has done outstanding work often independently of the Bureau of Science. Unfortunately the scope of this article is limited to the latter Bureau.

COÖPERATION

Coöperation has been the keynote in all the activities of the Bureau, particularly in medical research. For example, as early as 1915 the Director of Health began to send health officers to the Bureau for definite periods to obtain laboratory and practical instruction, a policy which was continued for several years. The International Health Division of The Rockefeller Foundation has been associated with the Bureau, first in 1921 and almost continuously since that time. So, too, the Japanese Army and Navy for the past ten years have been assigning medical officers to study at the Bureau. Other organizations in other countries have sent research workers from time to time, and to all the Bureau has extended a generous welcome. Many notable papers have resulted from these associations, as will be seen by consulting the bibliography. The association between the Bureau and the United States Army Medical Department has been very productive.

UNITED STATES ARMY MEDICAL DEPARTMENT RESEARCH BOARD

The United States Army Board for the Study of Tropical Diseases as They Exist in the Philippine Islands was reestablished in 1922 as The United States Army Medical Department Research Board, located at

the Bureau of Science. As noted by Simmons, who was president of the Board during the years 1928-30, this arrangement was advantageous, because the work at the Board was greatly facilitated through the close contact of its members with the personnel and the scientific resources of the Bureau.

Some of the work of this Board is not within the scope of this paper, since it was done elsewhere than at the Bureau of Science. The history of the Board has been ably written by Vedder, and his bulletin should be consulted for detailed information. However, even when the Board was not housed at the Bureau, it maintained cordial relations with the Bureau, and the Bureau conferred on the Board the privilege of using instruments, apparatus, and library. Vedder (p. 25) states that without the excellent library of the Bureau "it would be impossible to study the literature of any disease or problem, and it is difficult to realize how helpless the research worker is without adequate library facilities."

One cannot but feel pride in the work of this Army Board when one recalls Vedder's work, which demonstrated the amebicidal action of emetin *in vitro*; the work of Phelan and Kilbourne and of Chamberlain and Vedder in regard to fundamental factors in the cause, cure, and prevention of beriberi; Craig's extensive studies in malaria; the notable studies of Ashburn and Craig, Siler, Hall, and Hitchens, and of Simmons, St. John, Reynolds and Holt in dengue; of Holt in malaria and of Holt and Kintner in equine osteomalacia; and the long series of investigations by Phalen, by Chamberlain, and by Fleming on the subject of tropical climate and light as they affect human life in the Tropics. It has indeed been a notable chapter in the history of medical research. The part played by the Bureau of Science in its

affiliations with the Army Board has been acknowledged by all as of outstanding importance.

While there has been no such direct cooperation between the United States Navy and the Bureau of Science yet the Bureau has on many occasions afforded special opportunities to members of the medical personnel of the Navy. Stitt, for example, when assigned to Cafiacao Naval Station, made use of the special facilities of the Bureau. No doubt the Bureau may justly claim a part in Stitt's preparations for the publication of his notable and practical text books in clinical and laboratory tropical medicine. Garrison of the Navy served a two-year detail with the Bureau and published several papers dealing with parasitic infections.

RESEARCH

In the following pages I have attempted to review some of the notable products of medical research in the laboratories of the Philippine Bureau of Science. It is not possible to do justice to the many papers which have been published as a result of studies in the Bureau, but my hope is that this brief review will give some insight into the magnificent achievements of the Bureau of Science in the field of medical research. I have perforce had to omit references to veterinary science and to skim all too hurriedly over many phases of the medical studies. While the bibliography has been carefully prepared, I am afraid that important omissions may be noted. It should be remembered that at all times medical research has been only one phase of the scientific program of the Bureau, which has included chemistry, botany, mining, fisheries, ornithology, entomology, anthropology, and the publication of the *Philippine Journal of Science*. Although research in medical and allied sciences has

been only one phase of the program it has not been the least.

ASIATIC CHOLERA

It is not easy to visualize the devastation caused by the outbreak of cholera in the Philippines beginning in March 1902. But with nearly 4,000 deaths in two years' time in Manila and over 90,000 deaths in the provinces, one can understand why this terrible malady at once engaged the attention of medical research workers in the Government Laboratories. Strong, first director of the biological laboratory, at once began to study this disease. As a result of his investigations it was shown that cholera was being disseminated chiefly through foodstuffs, not through water supplies as in the classical Hamburg epidemic. Flies and water were only occasional sources of infection.

Strong also began intensive studies in an attempt to obtain practicable and efficacious protective inoculation against the disease. Haffkine's method had been tried but because of severe local and general reaction to the injection it was impossible to secure the coöperation of the people. It is noteworthy that Strong had begun his work in Berlin in the laboratories of Professor Wassermann in Koch's Institut für Infektionskrankheiten. Through Strong, that great German institute had a formative influence in the early days of the Bureau, setting the highest standards in medical research.

Others at the laboratory collaborated with Strong in his cholera studies. Wherry, for example, studied the biology of the cholera spirillum, particularly with reference to variations which may occur in a culture of the organism. Marshall showed that there is a great difference between individual strains of cholera, and that this variation is deep-seated.

Nichols, of the United States Army

Medical Corps, and Andrews, of the Bureau of Science, reported extensive investigations into the treatment of cholera during the 1908 epidemic in Manila, and confirmed, in a most useful way, the fact that intravenous injection of saline solution reduces by 80 per cent the mortality from collapse. They also remarked that nearly one-third of those who survived the state of collapse died later of uraemia, a condition for which there was no satisfactory treatment.

Ohno studied the behavior of cholera vibrios in culture media of different degrees of acidity and alkalinity. He found that different strains of cholera vibrios react differently toward acid and alkaline solutions, and that the medium in which the morphology appears most typical is different for different strains. He showed further that the more acidity or alkalinity of media is increased the more the agglutinability of the organism is decreased.

Sellards made a most significant contribution to the study of cholera when he found that cholera patients show a definite tolerance to alkalies, a considerable excess of sodium bicarbonate being required to render their urine alkaline, as compared with normal individuals. He demonstrated that the early administration of alkalies practically eliminated death from uraemia. This was an original finding of greatest importance, a definite contribution by the Bureau of Science to the treatment of cholera throughout the world.

Aron studied the chemistry of blood in cholera and found that in the collapse stage loss of water in the blood is regularly encountered, accompanied by a corresponding loss of chlorides. Later, the blood again acquires its normal content of water but the salts are not replaced, so that the blood is hypotonic.

McLaughlin, of the Health Service, and

Whitmore, of the Bureau, collaborated in a study of cholera and cholera-like vibrios found in the Philippines. Their work confirmed the belief that hogs do not act as cholera carriers. They also strengthened the observation that non-cholera vibrios will not agglutinate in specific anticholera serum in dilutions weaker than 1 to 10. They failed to find any haemolytic agglutinating strains of the "El Tor" type and they were unable to make cholera-like vibrios acquire agglutinability with cholera sera. McLaughlin at the Bureau of Science, while acting director of Health, was one of the first to demonstrate cholera carriers in the Philippines.

Crowell, on the basis of ninety-two autopsies on cases of cholera, outlined the anatomical features upon which a diagnosis can be made. Schöbl, in a study of the viability of cholera vibrios in Manila waters, found that vibrios disappeared first from distilled water and last from sea water, at room temperatures. They remained alive in tap water up to fifty-six days, and Schöbl therefore corroborated experimentally the theoretical possibility in the Philippine Islands of introducing Asiatic cholera from port to port by means of water carried on board ships. These studies also demonstrated that water polluted with human excreta may remain a source of cholera infection for considerable periods.

Schöbl also found experimentally that the inoculation of relatively few cholera vibrios into the gall bladder may produce carriers in animals and that the amount of inoculum appears not to have any direct bearing on the duration of the carrier state. Moreover, he showed that an increased flow of bile does not hasten the disappearance of cholera vibrios from either the gall passages or the intestine; in fact, the administration of cholagoges

tends to prolong rather than to shorten the duration of the carrier state.

Schöbl further showed that distribution of cholera vibrios in the alimentary canal of experimental cholera carriers fed on ox bile was more extensive, elimination of cholera vibrios in faeces was more constant, and cholera vibrios were present in the alimentary canal in larger numbers than in the case of the carriers that received no bile.

In collaboration with Pañganiban, Schöbl attempted preventive vaccination and vaccine therapy in guinea-pig cholera-carriers but failed to note any shortening in the duration of the carrier state. Specific immune bodies were shown to be present in the blood serum of experimental cholera carriers. Schöbl also made a useful survey of chemicals which might be used in the drug treatment of cholera carriers. These studies prepared the way for further investigations and indicated that such carriers by no means present a hopeless problem.

Crowell and Johnston, as a result of the examination of the intestinal contents and bile of 269 cases of cholera and of cholera carriers, made plain the importance of routine examinations of the bile as well as the faeces in suspected cases, because in some cases vibrios were found only in the bile.

Pañganiban and Schöbl experimented to find a method for the preservation of cholera stool specimens for delayed bacteriologic examination. They found that sodium chloride solution or ox bile gave good results. Schöbl and Andaya confirmed the observations made in other countries that immune bodies are found in the blood of persons vaccinated with cholera vaccine. They found antibodies persisting for from six to ten months and also showed that the degree and duration of immunity are directly dependent on the

amount of vaccine injected, but still more so on the number of injections given. They advised that wholesale vaccination in areas where outbreaks occur every year should be completed at least one month before the time when an epidemic might be expected, a point of considerable practical importance.

Schöbl and Ramirez, in a survey of artesian wells in Manila and vicinity, found cholera-like vibrios in seven of seventy-two artesian wells examined. They noted that cholera-like vibrios differ from true cholera vibrios in that they are not agglutinable by cholera serum and that when freshly isolated they are more strongly haemolytic than freshly isolated cholera strains. That they are closely related was indicated by their coincidence in cholera faeces and by the fact that cholera-like vibrios always increase in the faeces of a population immediately before an outbreak of cholera. This fact Schöbl and Ramirez showed to be of great significance from a sanitary and epidemiologic viewpoint. In the test for vibrios there is a very sensitive method for detecting faecal pollution of waters, food, vegetables, and various drinks.

PLAGUE

Herzog and Hare investigated the highly important question of whether or not, in an endemic area, plague may lie dormant in a population, ready at any time to flare up in an epidemic. At the time of their studies the question was more than hypothetical, because Manila was an endemic focus of bubonic plague. From their studies it was concluded that latent or dormant plague did not exist in the population of the Philippines.

Herzog published in 1904 a useful article on plague, which was based on twenty autopsies on patients succumbing to this

disease. This publication reviewed the question of plague diagnosis, offered an excellent guide for the performance of a systematic plague necropsy, and presented the author's investigations into the mode of dissemination of plague, at that time an undetermined problem. Herzog, in another paper, pointed out the frequent occurrence of renal hyaline-fibrin thrombosis in bubonic plague, a histopathologic change which he was first to described and to interpret.

Strong, in 1906, reviewed the question of prophylactic injections for plague, calling attention to the fact that, although various reports had been published of experiments with protective inoculations of killed organisms or their extracts, no successful experiments had ever been carried out with human vaccination, that is, with injections not of killed organisms but of living attenuated pest bacilli. Strong was the first to experiment with such plague vaccinations, and he showed that such injections could be made with safety. Although this method of protecting against plague did not prove to be as successful as was hoped, the experiments, in retrospect, were notable because they required unusual vision and courage.

In 1907 Strong reported further on his very extensive and intensive studies in plague immunity. It must be remembered that when Strong began his experiments the mode of plague transmission was still unproved. Vaccination seemed to offer the chief hope in combating this widespread and dangerous disease.

Seldom in the history of medical research throughout the world have more complete studies of a disease been made than were published in regard to pneumonic plague in 1912 by Strong and his colleagues Teague, Barber, and Crowell. During the winter of 1910-11 there had been, in Manchuria, an extensive outbreak

of pneumonic plague which overwhelmed the local medical personnel. There were 50,000 deaths. The Bureau of Science had made itself known as an oasis of scientific medicine in the Far East, so that it was natural for the State Department of the United States to call upon it for aid. The response of the Bureau was immediate, and not only did Strong and Teague from the Bureau of Science aid decisively in controlling the outbreak but they also very materially increased our knowledge of the etiology, bacteriology, pathology, clinical course, and prophylaxis of pneumonic plague. The American Red Cross met part of the expenses of the expedition.

When we recall that one is almost certain to acquire a fatal infection of this disease by merely walking, without proper masks and uniforms, through a ward filled with pneumonic plague patients, we can begin to realize the heroism with which these painstaking and monumental studies were made by the personnel of the Bureau of Science. Working all day, every day, throughout the epidemic, giving intravenous injections, leaning over coughing patients, making physical examinations and autopsies, these men, aided upon their return to laboratories of the Bureau by Barber and Crowell, were able to make the following observations:

1. During an epidemic of pneumonic plague the disease is spread directly from man to man by droplet infection and by more or less intimate contact of healthy individuals with infected persons. In no other disease is the individual so dangerous and in no other disease does danger from droplet infection approach that which exists in pneumonic plague.

2. That there could be a rapid spread of the pneumonic type of plague during a Manchurian winter and never in such a country or climate as in India or the Philippines was explained by Teague and

Barber on experimental grounds. They showed that the reason lay in the fact that fine droplets of pneumonic plague sputum disappear very quickly, with a consequent death by drying of the bacilli, except in places where the atmosphere has a very small water deficit. Such an atmosphere is rare in warm climates but common in very cold ones. Frozen pulverized sputum remains infective for long periods of time.

3. Infection in epidemic pneumonic plague results from inhalation, the primary point of infection being some portion of the bronchi, thence progress is made to the lungs where bacilli multiply rapidly to produce first lobular and then general lobar involvement of the lung tissue. Primary plague septicaemia sometimes occurs.

4. The organism of pneumonic plague is the *Bacillus pestis* of bubonic plague. Its virulence is no greater in one type of plague than in the other.

5. Prophylactic inoculation can not be relied upon even as a reasonable means of protection against pneumonic plague. A proper mask furnishes the only reliable method of protection.

Here, then, were classical papers in medical research emanating from the Bureau of Science.

AMOEBIASIS

Musgrave and Clegg in 1904 published an extensive study of amoebiasis. In this work they introduced the name "amebiasis" to cover all grades of infection and their term has since come into general use. They described methods by which amoebae could be secured in pure cultures not only from water, soil, and other substances, but from dysenteric stools and from ulcers in the human bowel. (This method was later shown not to apply to the *Entamoeba histolytica*.) The authors also studied the reactions of

amoebae to various physical conditions of light, heat, and moisture, and investigated the etiologic significance of the organisms. An extensive review of the literature was included. Musgrave also discussed thoroughly the prophylaxis and therapy of amoebiasis.

Walker studied the amoebae of Manila and concluded that those in the water supply are non-pathogenic. The pathogenic entamoebas he did not succeed in cultivating by Musgrave and Clegg's technique. Walker stated the important conclusion that a differential diagnosis could be made between *Entamoeba coli* and *Entamoeba histolytica* by microscopical examinations. He further noted the fact that the prophylaxis of amoebic dysentery is identical with that for other intestinal infections such as typhoid fever and cholera. Chamberlain and Vedder, in a series of experiments, demonstrated that ultra-violet rays will kill the amoebae, motile or encysted, in a water supply. Sellards investigated immunity reactions with amoebae and, in a series of experiments, demonstrated no production of immune bodies for amoebae in the sera of amoebic dysentery patients. Walker and Sellards undertook a notable series of experiments to determine experimentally the etiologic relationship of different species of amoeboid organisms to endemic tropical dysentery. It must be remembered that, at the time, the etiologic relationship of the entamoebae to dysentery was a much debated question, with views ranging all the way from an opinion that amoebae were guardians against disease in man to the view that all amoebae are or may become pathogenic.

Walker and Sellards, it should be noted, performed their experiments on human volunteers. The further one delves into the history of medical research at the Bureau of Science the more one is impressed

with the courage and intelligence of its scientists. Time and time again, as with plague, beriberi, yaws, dengue, and leprosy, obscure problems were attacked by direct human experimentation. It is doubtful if any other research institution the world over has such a notable record in this respect. Due honor has yet to be given the Bureau of Science for its contribution, along these lines, to medical science. Walker and Sellards used volunteers in Bilibid Prison who were therefore under complete experimental control. This was the first time amoebic dysentery had been studied by experiments upon man.

The conclusions of Walker and Sellards cover three pages of fine print and can be summarized only briefly here. Among other things, Walker and Sellards proved beyond cavil that *Entamoeba histolytica* is the essential etiologic factor in endemic tropical dysentery. The incubation period varied from 20 to 95 days. They showed that the "*Entamoeba tetragena*" of Viereck is identical with *Entamoeba histolytica* of Schaudinn, the "*tetragena*" cysts being developed in the life cycle of *Entamoeba histolytica*. They observed a large percentage of latent infections wholly consistent with and explanatory of clinical and pathological experience. They found the *entamoeba* to be an obligatory parasite, not propagated outside the body of its host, and they pointed out the danger of human carriers of the disease who are constantly passing in their stools the resistant, encysted stage of *Entamoeba histolytica*. These carriers, Walker and Sellards noted, are probably the chief agents in the dissemination of entamoebic dysentery.

Walker and Sellards, by their notable experiments, were able to put the diagnosis and prophylaxis of entamoebic dysentery upon a rational basis. Their work has stood the test of time and has not been

surpassed in excellence by any experiments anywhere in the study of the dysenteries. Sellards and Leiva studied experimentally treatment of amoebic dysentery in cats with emetine and with quinine, confirming results of other investigations. In another paper Sellards and Leiva, as the result of some experiments upon cats, concluded that stasis is probably an important factor in determining the location of lesions within the large bowel in spontaneous amoebic dysentery in man.

BACILLARY DYSENTERY

Barber published a study of certain strains of dysentery bacilli in which he utilized his famous method of isolating single cells. In this way his cultures were started with single bacilli and all chance of multiple strain culture was eliminated. Pañganiban and Schöbl modified the methylene blue-cosin-lactose medium and were able to report considerable improvement in diagnostic technic for the detection of *Bacillus dysenteriae*.

Kusama showed that the bacillus of dysentery is fairly resistant to drying. It will survive a considerable length of time in water, longer in sea water than in tap water. Vazquez-Colet demonstrated the existence of healthy carriers of *B. dysenteriae* in the Philippines and thus contributed to our knowledge of the local epidemiology of this disease. Morishima made some careful studies regarding the constancy of types of *Bacillus dysenteriae* and concluded that the classification, grouping, and subgrouping of *B. dysenteriae* are not of such importance as has seemed to be the case. The Shiga-Kruse group appeared to be stable but in the other main group there is considerable variability.

Lacy, and later Schöbl and Villaamil, investigated the serological grouping of *Bacillus dysenteriae*, contributing to a

better understanding of the basic factors underlying the practical diagnostic reactions of these dysentery organisms. One important point developed in these studies was that not only cultural but also biological and serological methods should always be employed in attempting a diagnosis of bacillary dysentery.

LEPROSY

In a paper based on the examination of several thousand lepers, Johnston commented on the varying morphology of the bacillus of leprosy. He concluded that examination of nasal mucus is of no value as a routine measure. Perkins discussed the chemistry of some drugs used in the treatment of leprosy. He also presented details regarding the manufacture of ethyl esters of chaulmoogra oil at the Bureau of Science. At that time about 40,000 doses a month were being manufactured.

Gomez and his colleagues reviewed the subject of early leprosy in children of lepers. They concluded that there is real danger to children who live in intimate contact with lepers, an important fact not then well known. They further noted that the most frequent recognizable site of early lesions of leprosy is the skin and the most frequent early sign is a macular whitish or fawn colored patch. Schöbl and his colleagues attempted by experimental laboratory evidence to answer certain questions on the chemotherapy of infectious diseases caused by acid-fast bacilli. They found, among other results, that chaulmoogra oil and its derivatives exert a pronounced and specific growth-inhibiting action on *Bacillus tuberculosis in vitro*. Other vegetable oils also inhibit the growth of acid-fast organisms but not so effectively as those of chaulmoogra and *hydnocarpus*. The vapor of these two oils shows no disinfecting effect, however. Schöbl noted

further that the growth-inhibiting activity of chaulmoogra oil depends on the structure of the ring of the fatty acids. When the structure of the ring is changed by saturation with hydrogen, the oil loses this biologic property. The acid-fast bacteria adapt themselves to the acids from the chaulmoogric series in due time and they withstand larger doses than they did originally. Saturated chaulmoogra oil lacks the growth-inhibiting activity toward acid-fast bacteria which is possessed by the unsaturated oil.

Callendar and Bitterman made an epidemiological study of leprosy in the Philippines. On the basis of the histories of some 259 lepers, they concluded that their evidence supported the view that the earliest lesion is an anesthetic area, that the organism probably enters the body through abrasions of the skin, that the more susceptible ages are in the first decades although no ages seemed exempt, and that further epidemiological studies in the Philippines are needed. Vedder emphasized the importance of further study of the possibility of insect born leprosy, demonstrating from an analysis of Philippine data that the evidence for transmission by contact is by no means complete. His three human experiments for transmission by *Aedes aegypti* were negative in the year of observation.

Schöbl and his colleagues demonstrated that advanced specific lesions can be produced by repeatedly inoculating Philippine monkeys with leprous material, and that these lesions closely resemble certain advanced lesions as known to exist in man. They noted a definite relationship between the forms and numbers of *B. leprae* and the stages of development of the advanced local skin lesions. Their experiments strongly suggested the possibility of studying certain phases of the course of leprosy infections and of immu-

nological reactions by experiments on monkeys.

In 1931 the director of the Bureau of Science, Dr. William H. Brown, was elected treasurer of the newly organized International Leprosy Association at a meeting held in Manila.

BERIBERI

In 1905 Herzog, of the Bureau of Science, was sent to Japan to study beriberi. A great number of cases had accumulated in the military reserve hospitals during the Russo-Japanese war, in fact the total number of cases of beriberi in the army was said to be about 80,000. An unusual opportunity was therefore presented to investigate this disease, known at the time to be prevalent in the Philippines. Herzog experimented with the Okata-Kukubo coccus which was thought to be the cause. He brought it back to Manila and reported that it did not seem to meet the requirements of a causative organism in his own experiments with monkeys. Herzog later prepare a review of the literature of beriberi and reported a series of autopsies in Manila. He came to the conclusion, which was in accord with numerous other investigators at the time, that beriberi was an infectious disease. He also mistakenly believed that infantile beriberi was not common in Manila.

McLaughlin and Andrews investigated infant mortality in Manila and among other findings reported that what they would call "infantile moist beriberi" was responsible for many more deaths than appeared to be the case from statistics, in fact it was the largest factor in the infant mortality of Manila. They did not determine the cause, although it is interesting that they stated that "it seems probable that there is an intimate relation between beriberi of infants and a mother's milk,

poor in quality and lacking certain necessary elements which are not included in the mother's dietary."

Chamberlain and Vedder, of the United States Army Board for the study of Tropical Diseases, had shown in a series of experiments, that the substance in rice polishings which prevents *Polyn neuritis gallinarum* was present in an extract of the polishings and that this neuritis-preventing principle was soluble in cold water or cold 95 per cent alcohol. The phosphorus, inorganic salts, and sucrose in this extract were, by experiments, excluded from further consideration as regards the prevention of neuritis. In a third paper these Army investigators collaborated with Williams of the Bureau of Science and the previous findings were further substantiated.

Strong and Crowell wrote, in 1912, that the etiology of beriberi was still a matter of some controversy and that, although numerous experiments had been reported, in which fowls were used, there had been not a single experiment upon man which from a scientific standpoint could be regarded as a crucial test. The only exception was the work of Fraser and Stanton in Malaya. These workers had published very suggestive data but concluded that further research was needed. Therefore Strong and Crowell set about to determine definitely whether beriberi as occurring in the Philippine Islands was an infectious disease or whether it was one which had its origin in disturbances of metabolism, brought about by the prolonged use of polished rice as a staple article of diet. Their experiments were carried out on thirty-nine prisoners in Bilibid. They concluded from their studies that there was no evidence that beriberi was an infectious disease. Beriberi in their experiments was produced only by means of a diet lacking in some substance

or substances necessary for the normal physiological processes of the body. Strong and Crowell noted that such substance or substances are evidently present in red rice and in rice polishings and also in a small amount in the alcoholic extract of rice polishings. These were notable experiments.

Vedder and Williams disproved experimentally the theory that beriberi may result from the use of undermilled rice which has been kept in a damp place. They found that even after a year's storage in a damp place undermilled rice still protected against *Polyn neuritis gallinarum*. They succeeded in curing a case of wet infantile beriberi by administering that portion of an extract of rice polishings represented by filtrate from phosphotungstic precipitate.

Williams and Saleeby, experimenting with twenty-seven cases of human beriberi, concluded that "the vitamine of rice polishings possesses specific and prompt curative properties far beyond those of any other known substance." Their work was noteworthy in that they used human patients instead of fowls. Williams and Crowell showed experimentally that there is no apparent fundamental connection between beriberi and atrophy of the thymus, as had been suggested by others.

Wells described the method used by the Bureau of Science in the manufacture of tikitiki extract for beriberi which had proved so useful that the demand at that time called for 15,000 bottles a month. Fleming found no significant differences between surgical convalescents and beriberi patients as regards basal metabolic rates and respiratory quotients.

Vedder and Feliciano examined some 200 samples of rice from different localities and all degrees of milling in order to determine some standards regarding the prevention of beriberi. They found that

no rice having 50 per cent or more of the external layers of the grain produced polyneuritis in pigeons. They also determined some chemical indices suitable for incorporation in legal regulations. Finally, their experiments made it seem probable that there may be a loss of vitamins from undermilled rice during long storage, due to the depredations of insects which have eaten the external layers of the grain.

YAWS

Woolley described some cases of a disease, called "lepra" by the Igorrotes, which he believed to be framboesia. Woolley's description is the first contribution of a long and very noteworthy series of papers on the subject of yaws by Bureau of Science personnel.

Ashburn and Craig, of the United States Army Board for the Study of Tropical Diseases, working in the Biological Laboratory of the Bureau of Science, were the first to prove that yaws was a fairly common disease in the Philippines. These investigators made fundamental and noteworthy studies.

Their work definitely proved that *Treponema pertenue* is the cause of yaws, and that it is constantly present in serum from yaws lesions. Moreover they demonstrated that monkeys can be infected with this organism, which can again be recovered from the simian lesions. By their study of yaws in monkeys they were able to conclude that yaws and syphilis are distinct diseases, and that the *Treponema pertenue* of yaws and *Treponema pallidum* of syphilis can be differentiated.

Marshall, in a histologic study, showed that the cellular pathology of simian and human yaws is essentially the same. In neither is there an endarteritis nor are there any other changes suggestive of syphilis. Strong received from Ehrlich a shipment of dioxidyamido-arsenobenzol

for experimental purposes with syphilis. When in Frankfurt, Strong had made arrangements with Ehrlich that he would send to the Bureau various new preparations to test their value for tropical affections. Because of the similarity between yaws and syphilis, Strong tried this new drug in cases of yaws. He demonstrated that the drug was an ideal specific for yaws. Bowman confirmed and supplemented Castellani's experiments with specific yaws antibodies and antigen, thus furnishing additional evidence as to the non-identity of syphilis and yaws.

Sellards, of the Bureau of Science, and Goodpasture and de Leon, of the College of Medicine, were associated in some investigations which included a study of the Wassermann reaction in yaws and the effect of treatment on this diagnostic test, the subject of immunity, the histology of healing lesions and, finally, the public health aspects of this disease, with suggestions for its control. They concluded that yaws was the one outstanding disease of the Tropics through the treatment of which the immediate confidence and enthusiasm of the people can be secured in public health work. This observation had since been abundantly confirmed in many tropical countries.

Lacy and Sellards, as a result of some inoculation experiments with human subjects, made a point, of practical significance, that yaws patients, treated in the advanced secondary stage of infection, remained in excellent health, free from any symptoms of yaws, and that they retained well-marked resistance to reinfection for more than two years. Such a period of time is enough to permit bringing the disease under control even in heavily infected districts. Sellards, Lacy, and Schöbl demonstrated in human volunteers that, in contrast to syphilis, superinfection with yaws is possible, even after

the typical primary granuloma has developed. These investigators also described some uncommon skin manifestations of yaws, concluding that, contrary to the usual belief, yaws may show almost as varied cutaneous lesions as syphilis.

Schöbl and Ramirez described experiments with the globulin precipitin reaction in which its independence of the Wassermann reaction was demonstrated and its practical value as a confirmatory test of clinical yaws in the pre-Wassermann stage was suggested.

Lopez-Rizal and Sellards found yaws widespread in the Mountain Province and noted that the cutaneous lesions, as seen in the mountain people, are peculiar in that they are usually limited to the mucocutaneous junctures of mouth, nose, anus, and genitalia.

Schöbl, in 1928, published a most important paper dealing with yaws. He clearly pointed out, in a lengthy and critical analysis of the literature, that although Castellani discovered the *Treponema pertenue* of yaws in 1906-07 yet twenty years later the mode of transmission of the disease among humans was not clear, the question of immunity was unsettled, and the question of the relation of yaws to syphilis still awaited an answer. He concluded that the local lesion produced by intradermal inoculation, as well as the early metastatic lesions of superinfection and the late yaws manifestations, like gangosa, are, in Philippine monkeys, clinically and anatomically identical with the corresponding lesions in man; the inoculation periods also are similar. Schöbl noted, further, the very important fact that the healing of existing yaws lesions, particularly the early ones, is independent of the resistance to superinfection. That is to say, yaws lesions in monkeys, as in men, may heal while the animal or man is still susceptible to super-

infection, and existing lesions will persist a long time after the stage of resistance to superinoculation has fully developed. Once the resistance to superinfection has been achieved, it is persistent, and no amount of treatment can cause the animal, once it has become resistant, to take infection again.

Yasuyama studied the viability of *Treponema pertenue* and published some original experimental data of importance. He found that the organism of yaws is unable to survive at low temperatures (0 to 5°C.) for more than 30 minutes, a fact which may explain why yaws, when introduced into a cold country, does not become endemic. Yasuyama found body temperature (37°C.) more favorable than room temperature. The viability of the organism outside the body was found to be limited to a few hours. In and on the bodies of flies the period of viability was found to be about thirty minutes.

Tanabe studied the Wassermann reaction in yaws in monkeys, concluding that such animals are suitable for the experimental study of this reaction. Alcohol was found to have the same effect on the Wassermann test in yaws as in syphilis. This constituted further proof of the identity of the reaction in Philippine monkeys and in syphilitic patients. Tanabe showed that when yaws has healed in monkeys, the immunity to reinoculation lasts longer than two years and probably for life.

Schöbl, Tanabe, Miyao, and Garcia studied certain serologic changes as they occurred in experimental framboesia in Philippine monkeys. They had found that when normal monkeys were injected subcutaneously with yaws material in such a manner that the development of skin lesions was prevented, the monkeys showed a strong Wassermann reaction although they did not become infected

with yaws. They do not have a latent infection of the internal organs. As a matter of fact, subcutaneous injections of killed *Treponema framboesiae* will produce this strong Wassermann reaction, which, after repeated injections, becomes weaker and finally negative. But injections of normal or inflammatory skin tissue from normal or yaws-infected monkeys, as well as injections of potent yaws vaccine, not containing treponemas, will not produce a positive Wassermann reaction. It was demonstrated that the skin tissues proper and not the lymphatic system or the muscles are responsible for the production of the Wassermann reagin. There is a positive reaction to the Kahn test in Philippine monkeys infected with yaws. The experiments indicated that the reagin of the Wassermann reaction is a true antibody of its kind. It is a direct serologic response to the antigen contained in the treponema and not merely a consequence of interaction between the viable treponemas and the tissues.

Although the close relationship between syphilis and yaws has been apparent for many years, very few experiments have been conducted to determine the immunologic reciprocity between these two diseases. Until Schöbl and his coworkers attacked the problem, there was no sound experimental evidence of any cross-immunity, in fact most workers in this field had convinced themselves that neither disease immunized against the other. It was Schöbl who noted that, although yaws monkeys (local yaws) were without exception inoculable with yaws for five months after the first inoculation, animals superinfected after the sixth month were, without exception, immune. During the sixth month only a certain percentage were immune. Furthermore, monkeys with generalized yaws were immune earlier than those with local yaws, while in

animals with late ulcerative lesions, the immunity was much delayed. Schöbl and Miyao, using only monkeys which had been successfully inoculated with yaws more than twelve months previously and which were proved to be immune to yaws, demonstrated conclusively that a high degree of immunity to yaws protects against cutaneous infection with syphilis in Philippine monkeys. Here was research of the highest order.

Schöbl and his confreres continued their yaws experiments, showing more and more clearly that there is a definite serologic reciprocity between yaws and syphilis. They noted that immunity to yaws produced by yaws vaccination prevented development of a specific syphilitic lesion, but did not necessarily prevent the penetration of treponemas of syphilis into regional lymph glands corresponding to the point of inoculation with syphilis. They repeatedly stressed the biologic difference between *Treponema framboesiae* and *Treponema luis*. The difference is one of organotropism or tissue selectivity. The treponema of syphilis is panblastotropic with a mesoblastic preference, being able to invade, multiply, or colonize all tissues. The treponema of yaws is epiblastotropic, invading, colonizing, and producing lesions only in certain tissues, particularly the skin. It may invade the mucous membrane by extension "*per continuitatem*" from the skin.

Schöbl's continued experimentation added confirmation to his earlier finding that immunity to yaws gained by yaws infection protects Philippine monkeys against cutaneous inoculation with syphilis.

Miyao reviewed the whole question concerning the relationship of yaws to syphilis, with a view to determining whether or not they are nosologic entities. He concluded that the two diseases belong

to one group and show a close relationship, but that they are fundamentally distinct. As was noted above, there is a basic biological difference in the organotropism of the two treponemas.

Schöbl demonstrated that the immunologic reciprocity between yaws and syphilis is a group immunity not dissimilar to that group relationship known to exist in bacterial immunity. Monkeys infected with syphilis became immune to syphilis much sooner than they did to yaws and monkeys infected with yaws became immune to yaws sooner than to syphilis. Immunity to syphilis, like immunity to yaws, seems to last throughout the natural life of Philippine monkeys. The anti-treponematous immunity in vaccinated monkeys that had been proved immune to skin inoculation with yaws and syphilis was shown to be of as long duration as the immunity induced by infection accompanied by specific skin lesions. Vaccine therapy with killed syphilis vaccine, performed on yaws-infected and early-treated monkeys, accelerates the onset of immunity to yaws. Infection with syphilis immunizes Philippine monkeys against yaws. Mesodermal inoculation with yaws immunizes against epidermal infection with yaws.

Schöbl, on the basis of his seven years' study of experimental yaws and syphilis in monkeys, offered an interpretation of the laws of Brown and Pearce. These laws were deduced by the authors as a result of their studies of experimental syphilis in rabbits. The law of inverse proportions, to the effect that the more intensive the early manifestations the less intensive the late manifestations, was interpreted by Schöbl as a direct proportion between the quantity of treponematous antigen, dead or alive, and the degree of immunity and the speed of its development. The law of sequence, to

the effect that the various systems of tissues are affected successively, was interpreted by Schöbl as a successive development of immunity in the various systems of the body's tissues. This view, based on Schöbl's extensive and intensive studies, brought the laws of Brown and Pearce into agreement with the laws governing antibacterial immunity and constituted a noteworthy contribution to the knowledge of tissue immunity. Schöbl predicts that the question of organotropism with regard to infection and immunity very likely will be found to have a more general application than is suspected today.

Conceptions of immunity must be modified as a result of Schöbl's work. Moreover, as a result of Schöbl's monumental researches in the treponematoses, we may hope that one day vaccination will be a practical weapon in our attempts to combat yaws and syphilis, more particularly, of course, the latter. Surely we may class these biological studies of Schöbl and his associates at the Bureau of Science as among the best in the history of medical research throughout the scientific world.

MISCELLANEOUS

This review would far exceed the limits set for it if all the papers resulting from medical research at the Bureau of Science were reviewed even as briefly as those already mentioned. It must suffice to note that the investigations at the Bureau have delved into every phase of medicine as it concerns life and health in the Philippines. For example, there have been surveys and studies in trematode infestations by Woolley, Musgrave, Phalen and Nichols, Garrison and Leynes, and culminating in the researches of Tubangui, who has traced, for the first time, the life cycle of the Schistosomiasis parasite as it

is found in the Philippines. Skin infections and ulcerations have been studied by Strong, Musgrave, and Clegg, Shattuck, Lefebvre, Schöbl, and others. Filariasis surveys were made by Phalen and Nichols and by Walker. Smallpox was studied by Brinckerhoff and Tyzzer, of the Harvard Medical School Smallpox Commission, who added much to the world's knowledge of this disease.

Musgrave and Sison published clinical data, and Crowell added some notes on pathology, regarding the bone lesions of smallpox. These lesions are typical and although recently described again by others were first noted by these authors.

Malaria and *Anopheles* mosquitoes have been investigated by Walker and Barber, by Baisas, King, and others. McKinley prepared an exhaustive monograph on filterable viruses, making use of the unexcelled facilities of the Bureau of Science library.

Barber, in 1914, published the perfection of his highly original and notable method of isolating single organisms under microscopical control by means of a very fine-pointed, capillary pipette of glass. Barber's technique prepared the way for the numerous micro-manipulators now available.

Fleming has studied tropical light, and there have been many important researches into the etiology and clinical manifestations of dengue by members of the Medical Department Research Board of the United States Army while working at the Bureau of Science.

Intestinal parasitism has been investigated in the field and in the laboratory by Bowman, Willets, Rissler and Gomez, Gomez, Walker, Crowell and Hammack, and by Leach, Schwartz, and Haughwout.

Investigations were made of Philippine foods and foodstuffs, particularly of soy bean and rice bran, culminating in the

contemporary and notably practical publications of Miss Orosa.

Vazquez-Colet and also Schöbl, Hirano, Ramirez, and Arima have studied rat-bite fever. Schöbl's observation that the distribution of rat-bite fever in Manila coincides with that of plague during the last epidemic is of particular significance.

A perusal of the appended bibliography will reveal many other papers of unusual interest.

It would require more space than is available to do justice to these miscellaneous papers, many of which had unique value. All-in-all, the record of the Bureau of Science, Manila, is one of real achievement in the field of tropical biology and medicine. Musgrave, in his review in 1911 of the progress of medical research in the Philippines, did not exaggerate when he wrote that

Research and investigation have made successful public health administration possible in this country, and the availability and convenience at all times of a trained corps of investigators to the administrators of public health affairs has resulted in an unusually high scientific plane of campaign of preventive medicine.

SUMMARY

This paper reviews the history of the Philippine Bureau of Science. It discusses the biological and medical research which has been done at this institution since 1901. It calls attention to the fact that routine work and research have been blended at the Bureau of Science to the advantage of each.

The paper notes certain fundamental advances which have resulted from studies by personnel of the Bureau in the field of tropical medicine, especially in beriberi, cholera, plague, bacillary and amoebic dysentery, leprosy, and yaws. An extensive bibliography is appended.

The author is greatly indebted to Doctors Strong, Sellards, Crowell, Gay, and Schöbl for their comments on the manuscript of this paper.

LIST OF LITERATURE

In the following bibliography *PJS* denotes the *Philippine Journal of Science*

A General

- 1 CALVERT, W J Circular No 3 on tropical diseases (Bubonic plague) Chief Surgeon's Office, Headquarters, Division of the Philippines, *Manila, P I* (May, 1901) 1-39
- 2 FORBES, W C The Philippine Islands Houghton Mifflin Co II (1928) 351
- 3 FORBES, W C The Philippine Islands Houghton Mifflin Co II (1928) 364-365
- 4 MUGRAVE, W E The progress of medical research in the Philippine Islands *Bull Manila Med Soc*, 3 (1911) 122-126, 138-144
- 5 SIMMONS, J S The United States Army Medical Department Research Board *Milit Surg*, 67 (1930) 479-489
- 6 STRONG, R P, and MUGRAVE, W E The occurrence of Malta fever in Manila *Philadelphian Med J*, Nov 24 (1900) reprint of 12 pages
- 7 STRONG, R P, and MUGRAVE, W E Preliminary note of a case of infection with *Balamidium coli* (Stein) *Johns Hopkins Hosp Bull*, 12 (1900) reprint of 4 pages
- 8 STRONG, R P Circular No 1 on tropical diseases (animal parasites) Chief Surgeon's Office, Headquarters, Division of the Philippines, *Manila, P I* (Feb, 1901) 1-45
- 9 STRONG, R P, and MUGRAVE, W E Circular No 2 on tropical diseases Etiology of the dysenteries of the Philippine Islands Chief Surgeon's Office, Headquarters, Division of the Philippines, *Manila, P I* (April, 1901) 1-54
- 10 STRONG, R P The Bureau of Government Laboratories for the Philippine Islands Scientific positions under it, etc *Am Med*, 5 (1903) 665-667
- 11 VEDDER, E B A synopsis of the work of the Army Medical Research Board in the Philippines *Army Med Bull*, (1929) 1-179
- 12 ANNUAL REPORTS, Bur Gov Lab, P I, (1902-1904)
- 13 ANNUAL REPORTS, Bur of Sci, P I, (1905-1932)
- carriers of the vibrio of Asiatic cholera. *PJS*, 9B (1914) 1-4
3. CROWELL, B C Notes on the diagnosis of Asiatic cholera at autopsy *PJS*, 9B (1914) 361-365
- 4 CROWELL, B C, and JOHNSTON, J A Bacteriological investigation of faeces and bile of cholera cases and cholera carriers *PJS*, 12B (1917) 85-103
- 5 GARCIA, O Notes on the serological relationship of the cholera-like vibrio isolated from human beings and from waters in Manila *PJS*, 36 (1928) 187-198
- 6 GOMEZ, L P Diagnostico bacteriologico del colera morbo asiatico *Revista Fisip de Med y Farm*, 1 (1910) 139-142
- 7 JOHNSTON, J A Some bacteriologic phases of the cholera-like carrier problem *PJS*, 14 (1919) 459-464 [Also published in *Asamblea Regional de Medicos y Farmaceuticos de Filipinas, 4th Actas, Memorias, y Comunicaciones* (1918) 403-408]
- 8 McLAUGHLIN, A J, and SELLARDS, A W Effect of the concentration of solution in the treatment of collapse in Asiatic cholera *PJS*, 5B (1910) 391-394
- 9 McLAUGHLIN, A J, and WHITMORE, E R Cholera and cholera-like vibrios encountered in the Philippines *PJS*, 5B (1910) 403-432
- 10 MARSHALL, H T Studies of cholera *PJS*, 3B (1908) 107-120
- 11 NICHOLS, H J, and ANDREWS V L The treatment of Asiatic cholera during the recent epidemic *PJS*, 4B (1909) 81-98
- 12 OHNO, Y K The reaction of culture media in relation to the morphology of the cholera organism *PJS*, 4B (1909) 341-352
- 13 PAÑGANIBAN, C S, and SCHÖBL, O Preservation of cholera stool specimens for delayed bacteriologic examination *PJS*, 13B (1918) 275-280
- 14 SCHÖBL, O The viability of the cholera vibrio in Manila waters *PJS*, 9B (1914) 479-481
- 15 SCHÖBL, O Observations concerning cholera carriers *PJS*, 10B (1915) 11-17
- 16 SCHÖBL, O Practical experience with some-enriching media recommended for bacteriological diagnosis of Asiatic cholera *PJS*, 10B (1915) 127-144
- 17 SCHÖBL, O The influence of bile upon the duration of the state of cholera carriers in experimental animals *PJS*, 11B (1916) 157-158

B Asiatic cholera

- 1 ARON, HAUS The chemical composition of the blood in Asiatic cholera *PJS*, 5B (1910) 395-401.
- 2 BARBER, M A Cockroaches and ants as

- 18 SCHÖBL, O The relation between the amount of cholera culture injected into the gall bladder and the state of cholera carriers in experimental animals *PJS*, 11B (1916) 153-155
- 19 SCHÖBL, O The influence of bile upon the distribution of cholera vibrios in the digestive system of experimental cholera carriers *PJS*, 12B (1917) 23-24
- 20 SCHÖBL, O, and PAÑGANIBAN, C S Experimental cholera carriers and immunity *PJS*, 12B (1917) 43-49
- 21 SCHÖBL, O A survey of certain chemicals with regard to their bactericidal action on cholera vibrios within the body of experimental cholera carriers *PJS*, 12B (1917) 215-231
- 22 SCHÖBL, O Experimental cholera-carriers *Asamblea Regional de Medicos y Farmaceuticos de Filipinas, 4th Actas y Comunicaciones*, (1919) 401-402. [Also published in *Rev Filip de Med y Farm*, 10 (1919) 213-215]
- 23 SCHÖBL, O, and ANDAYA, J Cholera vaccination, its effectiveness as evidenced by the course of antibodies in the blood of vaccinated persons *PJS*, 26 (1925) 311-316
- 24 SCHÖBL, O, and ROSARIO-RAMIREZ, T V Bacteriological survey of artesian wells in Manila and vicinity *PJS*, 45 (1931) 201-210
- 25 SELLARDS, A W Tolerance for alkalis in Asiatic cholera *PJS*, 5B (1910) 363-390
- 26 SELLARDS, A W, and IHAKLEE, A O Indications of acid intoxication in Asiatic cholera *PJS*, 6B (1911) 53-76
- 27 STRONG, R P Asiatic cholera *Bur of Sci P I, An Rept*, 1-3 (1902-4) 570-572
- 28 STRONG, R P A practicable cholera vaccine and its method of preparation *Bur of Sci P I, An Rept*, 1-3 (1902-4) 588-591
- 29 STRONG, R P Protective inoculation against Asiatic cholera (an experimental study) *Manila*, Bur of Print (1904) [*Bur Govt Lab P I, Pub*, No 16]
- 30 STRONG, R P The investigations carried on by the biological laboratory in relation to the suppression of the recent cholera outbreak in Manila *PJS*, 2B (1907) 413-439
- 31 WHERRY, W B II A search into the nitrate and nitrite content of Wute's Pepton, with special reference to its influence on the demonstration of the indol and cholera-red reactions *Manila*, Bur of Print (1905) [*Bur Govt Lab P I, Pub*, No 31]
- 32 WHERRY, W B Some observations on the biology of the cholera spirillum *Manila*, Bur of Print (1905) [*Bur Govt Lab P I, Pub*, No 19]

C. Plague

- 1 BARBER, M A Studies on pneumonic plague and plague immunization I Immunization of guinea pigs by vaccination with avirulent plague mixed with agar *PJS*, 7B (1912) 245-250
- 2 BARBER, M A Studies on pneumonic plague and plague immunization XI The infection of guinea pigs, monkeys, and rats with doses of plague bacilli, ranging from one bacillus upwards *PJS*, 7B (1912) 251-254
- 3 BARBER, M A, and TEAGUE, O Studies on pneumonic plague and immunization XII Some experiments to determine the efficacy of various works for protection against pneumonic plague *PJS*, 7B (1912) 255-268
- 4 BARBER, M A The susceptibility of cockroaches to plague bacilli inoculated into the body cavity *PJS*, 7B (1912) 521-524
- 5 CROWELL, B C Pathologic anatomy of bubonic plague *PJS*, 10B (1915) 249-306
- 6 HERZOG, M, and HARE, C B I Does latent or dormant plague exist where the disease is endemic? *Manila*, Bur of Print (1904) [*Bur Govt Lab P I, Pub*, No 20]
- 7 HERZOG, M The plague bacteriology, morbid anatomy, and histopathology Including a consideration of insects as plague carriers *Manila*, Bur of Print (1904) [*Bur Govt Lab P I, Pub*, No 33]
- 8 HERZOG, M Further observations on fibrin thrombosis in the glomerular and other renal vessels in bubonic plague *Manila*, Bur of Print (1905) [*Bur Govt Lab P I, Pub*, No 33]
- 9 RÜDIGER, E H The relation between the physical condition of cattle and their resistance to cattle plague *Manila Med Soc Bull*, 2 (1910) 291-294
- 10 SCHÖBL, O Bacteriological observations made during the outbreak of plague in Manila in 1912 *PJS*, 8B (1913) 409-427
- 11 SCHÖBL, O Plague Its Causes and the Manner of Its Extension, Its Control and Suppression, Its Diagnosis and Treatment (By T Wright Jackson with bacteriological observations by O Schöbl) (1916) 192 pp Lippincott
- 12 STRONG, R P Vaccination against plague *PJS*, 1 (1906) 181-190
- 13 STRONG, R P A consideration of some of Bail's recent views in connection with the study of immunity and a comparison of the value of protective inoculation with aggrasin with that of vaccination in plague *PJS*, 1 (1906) 501-512.

14. STRONG, R. P. Studies in plague immunity. *PJS.*, 2B (1907) 155-331.
 15. STRONG, R. P. Studies on pneumonic plague and plague immunization. I. Introduction. The expedition to Manchuria and the conditions under which the work was performed there. *PJS.*, 7B (1912) 129-136.
 16. STRONG, R. P., and TEAGUE, O. Studies on pneumonic plague and plague immunization. II. The method of transmission of the injection in pneumonic plague and manner of spread of the disease during the epidemic. *PJS.*, 7B (1912) 137-156.
 17. STRONG, R. P., and TEAGUE, O. Studies on pneumonic plague and plague immunization. IV. Portal of entry of infection and method of development of the lesions in pneumonic and primary septicæmic plague: experimental pathology. *PJS.*, 7B (1912) 173-180.
 18. STRONG, R. P., and TEAGUE, O. Studies on pneumonic plague and plague immunization. V. Clinical observations. *PJS.*, 7B (1912) 181-185.
 19. STRONG, R. P., and TEAGUE, O. Studies in pneumonic plague and plague immunization. VI. Bacteriology. *PJS.*, 7B (1912) 187-202.
 20. STRONG, R. P., *et al.* Studies on pneumonic plague and plague immunization. VII. Pathology. *PJS.*, 7B (1912) 203-221.
 21. STRONG, R. P., and TEAGUE, O. Studies on pneumonic plague and plague immunization. VIII. Susceptibility of animals to pneumonic plague. *PJS.*, 7B (1912) 223-228.
 22. STRONG, R. P., and TEAGUE, O. Studies on pneumonic plague and plague immunization. IX. Protective inoculation against pneumonic plague. *PJS.*, 7B (1912) 229-243.
 23. TEAGUE, O., and BARBER, M. A. Studies on pneumonic plague and plague immunization. III. Influence of atmospheric temperature upon the spread of pneumonic plague. *PJS.*, 7B (1912) 157-172.
- D. Amoebiasis*
1. CHAMBERLAIN, W. P., and VEDDER, E. B. The effect of ultraviolet rays on amoebæ, and the use of these radiations in the sterilization of water. *PJS.*, 6B (1911) 383-394.
 2. HAUGHWOUT, F. G. Some departures from the typical cell picture of bacillary and amoebic dysentery with speculations as to their significance, I. *PJS.*, 25 (1924) 513-537.
 3. MARSHALL, H. T. An unusual case of amoebic dysentery. *PJS.*, 4B (1909) 303-309.
 4. MUGRAVE, W. E., and CLEGG, M. T. I. Amebas: their cultivation and etiologic significance. *Manila*, Bur. of Print. (1904) 1-89. [*Bur. Govt. Lab. P. I., Pub.*, No. 18, Biol. Lab.]
 5. MUGRAVE, W. E. II. Treatment of intestinal amoebiasis (amebic dysentery) in the tropics. *Manila*, Bur. of Print. (1904) 91-117. [*Bur. of Govt. Lab. P. I., Pub.*, No. 18, Biol. Lab.]
 6. MUGRAVE, W. E. Amoebiasis: its association with other diseases, its complications, and its aftereffects. *PJS.*, 1 (1906) 547-573.
 7. MUGRAVE, W. E., and CLEGG, M. T. The cultivation and pathogenesis of amoebæ. *PJS.*, 1 (1906) 909-950.
 8. MUGRAVE, W. E. Intestinal amoebiasis without diarrhea; a study of fifty fatal cases. *PJS.*, 5B (1910) 229-231.
 9. SELLARDS, A. W. Immunity reactions in the amoebæ. *PJS.*, 6B (1911) 281-298.
 10. SELLARDS, A. W., and LEIVA, L. Investigations concerning the treatment of amoebic dysentery. *PJS.*, 22 (1923) 1-37.
 11. SELLARDS, A. W., and LEIVA, L. The effect of stasis on the development of amoebic dysentery in the cat. *PJS.*, 22 (1923) 39-42.
 12. STRONG, R. P. Intestinal hemorrhage as a fatal complication in amoebic dysentery and its association with liver abscess. *Manila*, Bur. of Print. (1905) 1-15. [*Bur. Govt. Lab. P. I., Pub.*, No. 32, Biol. Lab.]
 13. THOMAS, J. B. II. The action of various chemical substances upon cultures of amoeba. *Manila*, Bur. of Print. (1905) 17-29. [*Bur. Govt. Lab. P. I., Pub.*, No. 32, Biol. Lab.]
 14. VEDDER, E. B. A preliminary account of some experiments undertaken to test the efficacy of the ipecac treatment of dysentery. *Bull. Manila Med. Soc.*, 3 (1911) 48-53.
 15. WALKER, E. L. A comparative study of the amoebæ in the Manila water supply, in the intestinal tract of healthy persons, and in amoebic dysentery. *PJS.*, 6B (1911) 259-279.
 16. WALKER, E. L., and SELLARDS, A. W. Experimental entamoebic dysentery. *PJS.*, 8B (1913) 253-331. Spanish translation in *Rev. Filip. de Med. y Farm.*, 4 (1913) 665-679.
 17. WHITMORE, E. R. Parasitic amoeba in the intestine of man, with a study of amoebæ from various sources in Manila. *Asamblea Regional de Médicos y Farmacéuticos de Filipinas. 1st. Memorias y Comunicaciones*, (1912) 157-162.
 18. WILLETS, D. G., *et al.* Preliminary report on the treatment of entamoebiasis with ipecac,

emetine, and neosalvarsan at the Philippine General Hospital, Manila, P. I. *PJS.*, 9B (1914) 93-117.

B. Bacillary dysentery

1. BARBER, M. A. The variability of certain strains of dysentery bacilli studied by the single-cell method. *PJS.*, 8B (1913) 539-559.
2. BOWMAN, F. B. A series of cases of tropical infantile dysentery with a hitherto undescribed bacillus as the causative factor (Preliminary report). *PJS.*, 3B (1908) 31-38.
3. BOWMAN, F. B. A note on the spontaneous occurrence of bacillary dysentery in monkeys. *PJS.*, 5B (1910) 481-484.
4. BOWMAN, F. B. A case of dysentery caused by *Balantidium coli* with coincident filarial infarction of the spleen. *PJS.*, 6B (1911) 147-153.
5. FREER, P. C. The preparation of benzoyl-acetyl peroxide, and its use as an intestinal antiseptic in cholera and dysentery. Preliminary notes. *Manila*, Bur. of Print. 1904. 19 pp. [*Bur. Govt. Lab. P. I., Pub., No. 2, Chem. Lab.*]
6. HAUGHWOUT, F. G., DOMINGO, E., and DE LEON, W. Protozoologic and clinical studies on the treatment of protozoal dysentery with benzyl benzoate. *PJS.*, 16 (1920) 633-646.
7. HAUGHWOUT, F. G. Observations on the differential diagnosis of the dysenteries. *J. Philsp. Is. Med. Assn.*, 1 (1921) 53-58.
8. HAUGHWOUT, F. G. Observations on the microscopical picture in dysentery and other intestinal disorders. *Trans. 5th. Congr. Far East. Assn. Trop. Med.*, (1923).
9. HAUGHWOUT, F. G. Some departures from the typical cell pictures of bacillary and amoebic dysentery, with speculation as to their significance. I. Observations on some post-bacillary exudates and on the presence of eosinophiles in intestinal allergy. *PJS.*, 25 (1924) 513-537.
10. HAUGHWOUT, F. G. The practical microscopic diagnosis of dysentery. *Med. Bull. No. 3* (1924) *Ind. Med. Res. Kuala Lumpur, F. M. S.*
11. HAUGHWOUT, F. G. The microscopic diagnosis of dysenteries at their onset. *J. Am. Med. Assn.*, 83 (1924).
12. KUBAMA, H. A note on the viability of *Bacillus dysenteriae*. *PJS.*, 27 (1925) 1-7.
13. LACY, G. R. A report of typical and atypical *Bacillus dysenteriae* Shiga, with special reference to agglutination reactions. *PJS.*, 28 (1925) 313-328.

14. MORISHIMA, KAN-ICHIRO. Experimental inquiry into the constancy of types of *Bacillus dysenteriae*. *PJS.*, 29 (1926) 447-462.
15. PAÑGANIBAN, C. S., AND SCHÖBL, O. Experience with methylene blue-eosin lactose agar in searching for *Bacillus dysenteriae* in stools. *PJS.*, 14 (1919) 235-237.
16. SCHÖBL, O. Review of investigations on bacillary dysentery. *Far East. Assn. Trop. Med.*, 2 (1925) 387-394.
17. SCHÖBL, O., AND VILLAAMIL, R. Contribution to the serologic grouping of *Bacillus dysenteriae* based upon the quality of antigen and normal agglutinins. *PJS.*, 30 (1926) 1-38.
18. SCHÖBL, O., AND VILLAAMIL, R. Note on bacteriological diagnosis of bacillary dysentery. *PJS.*, 35 (1928) 133-148.
19. VAZQUEZ-COLET, A. Contribution to the question of dysentery carriers in the Philippine Islands. *PJS.*, 28 (1925) 173-192.
20. WHITMORE, E. R. The dysentery bacillus with a bacteriologic study of an epidemic of bacillary dysentery in the Philippines. *PJS.*, 6B (1911) 215-227.

F. Leprosy

1. BRILL, H. C., AND WILLIAMS, R. R. The use of chaulmoogra oil as a specific for leprosy. *PJS.*, 12A (1917) 207-220.
2. BRILL, H. C. Chaulmoogra oil. *Asamblea Regional de Medicos y Farmaceuticos de Filipinas, 3d. Actas, Memorias, y Comunicaciones*, (1917) 551-553.
3. CALLENDER, G. R., AND BITTERMANN, T. An epidemiological study in leprosy. *PJS.*, 27 (1925) 9-18.
4. CLEGG, M. T. Some experiments on the cultivation of *Bacillus leprae*. *PJS.*, 4B (1909) 77-142.
5. CLEGG, M. T. The cultivation of the leprosy bacillus. *PJS.*, 4B (1909) 405-415.
6. CLEGG, M. T. Leprosy. *Manila Med. Soc. Bull.*, 2 (1910) 308-312.
7. GOMEZ, L., BASA, J. A., AND NICOLAS, C. Early lesions and the development and incidence of leprosy in children of lepers. *PJS.*, 21 (1922) 233-256.
8. JOHNSTON, J. A. A contribution to the bacteriology of leprosy. *PJS.*, 9B (1914) 227-230.
9. JOHNSTON, J. A. Leprosy. *PJS.*, 10B (1915) 365-370.
10. JOHNSTON, J. A. The varying morphology of *Bacillus leprae* and the routine microscopic examination of nasal mucus in lepers. *PJS.*, 12B (1917) 115-118.

11. PERKINS, G. A. The preparation of certain drugs used in the treatment of leprosy. *J. Philip. Is. Med. Assn.*, 1 (1921) 62-67.
12. PERKINS, G. A. Manufacture of certain drugs for the treatment of leprosy. *PJS.*, 21 (1922) 1-14.
13. SCHÖBL, O. Chemotherapeutic experiments with chaulmoogra and allied preparations. *PJS.*, 23 (1923) 533-542. [Also published in *Far East Assn. Trop. Med. 6th Cong. Trans.*, Tokyo, 1 (1925) 1011-1014.]
14. SCHÖBL, O., and BASACA, M. Contribution to the serology of leprosy. *PJS.*, 25 (1924) 1-9.
15. SCHÖBL, O. Chemotherapeutic experiments with chaulmoogra and allied preparations. II. Comparison of the antiseptic power of chaulmoogra oil with that of other vegetable and animal oils, rare and common. *PJS.*, 24 (1924) 23-27.
16. SCHÖBL, O. Chemotherapeutic experiments with chaulmoogra and allied preparations. IV. A survey of certain organic compounds as to their growth-inhibiting activity toward acid-fast bacilli *in vitro*. *PJS.*, 25 (1924) 123-134.
17. SCHÖBL, O. Chemotherapeutic experiments with chaulmoogra and allied preparations. V. An inquiry into the mechanism and nature of the growth-inhibiting effect of chaulmoogra and other vegetable oils. *PJS.*, 25 (1924) 135-150.
18. SCHÖBL, O., and KURAMA, H. Chemotherapeutic experiments with chaulmoogra and allied preparations. III. The disinfecting power of the vapors of vegetable oils toward acid-fast bacteria. *PJS.*, 24 (1924) 443-445.
19. SCHÖBL, O., and RAMIREZ, J. Serological analysis of lepers' sera. *PJS.*, 29 (1926) 305-326.
20. SCHÖBL, O., PINEDA, E. V., and MIYAO, I. Clinical skin lesions in Philippine monkeys resulting from experimental inoculation with human leprosy material. *PJS.*, 41 (1930) 233-243.
21. TRAGUE, O. The cutaneous reaction in leprosy. Preliminary report. *PJS.*, 4B (1909) 323-327.
22. TRAGUE, O. The Nastin treatment of leprosy. *PJS.*, 4B (1909) 329-331.
23. VEDDER, E. B. A discussion of the etiology of leprosy, with especial reference to the possibility of the transference of leprosy by insects, and the experimental inoculation of three men. *PJS.*, 37 (1928) 215-243.
24. WHITMORE, E. R., and CLEGG, M. T. The specific treatment of leprosy. *PJS.*, 5B (1910) 559-562.
- G. Beriberi
1. CHAMBERLAIN, W. P. The eradication of beriberi from the Philippine (native) scouts by means of a simple change in their dietary. *PJS.*, 6B (1911) 133-146.
2. CHAMBERLAIN, W. P., et al. A study of the influence of rice diet and of inanition on the production of multiple neuritis of fowls and the bearing thereof on the etiology of beriberi. *PJS.*, 6B (1911) 177-209.
3. CHAMBERLAIN, W. P., and VEDDER, E. B. A contribution to the etiology of beriberi. *PJS.*, 6B (1911) 251-258.
4. CHAMBERLAIN, W. P., and VEDDER, E. B. A second contribution to the etiology of beriberi. *PJS.*, 6B (1911) 395-404.
5. CHAMBERLAIN, W. P. Prevention of beriberi among Philippine scouts by means of modifications in the diet. *J. Am. Med. Assn.*, 64 (1915) 1215-1220. [Reviewed in *Rev. Fil. de Med. y Farm.*, 2 (1915) 541-42.]
6. CHAMBERLAIN, W. P., et al. A third contribution to the etiology of beriberi. *PJS.*, 7B (1912) 39-52.
7. CHAMBERLAIN, W. P. The eradication of beriberi from the Philippine (native) scouts by means of a single change in their dietary. *PJS.*, 6B (1911) 133-147. [Reviewed in *Rev. Filip. de Med. y Farm.*, 6 (1915) 498-500, also in *Man. Med. Soc. Bull.*, 4 (1912) 26-33.]
8. FLEMING, Wm. D. Metabolic mechanism in beriberi. *PJS.*, 23 (1923) 407-411.
9. HERMANO, A. J., and ANIDO, FÉ. Chemical and biological analyses of tikitiki extracts. *PJS.*, 50 (1933) 189-197.
10. HERZOG, MAXIMILIAN. Beriberi in the Japanese Army during the late war; the Kakke coccus of Okata-Kokubo. *PJS.*, 1 (1906) 169-180.
11. HERZOG, M. Studies in beriberi. *PJS.*, 1 (1906) 709-764.
12. KILBOURNE, E. D. Food salts in relation to beriberi. *PJS.*, 5B (1910) 127-135.
13. McLAUGHLIN, A. J., and ANDREWS, V. L. Studies in infant mortality. *PJS.*, 5B (1910) 149-160.
14. SALSBY, N. M. The treatment of human beriberi in the autolyzed yeast extract. *PJS.*, 14 (1919) 11-12.
15. STRONG, R. P., and CROWELL, B. C. The etiology of beriberi. *PJS.*, 7B (1912) 271-413. [Spanish translation in *Rev. Filip. de Med. y Farm.*, 4 (1913) 293-312.]
16. VEDDER, E. B., and CLARK, E. A study of polyneuritis gallinarum. A fifth contribu-

- tion to the etiology of beriberi. *PJS.*, 7B (1922) 423-461.
17. VEDDER, E. B., and WILLIAMS, R. R. Concerning the beriberi-preventing substances or vitamins contained in rice polishings; a sixth contribution to the etiology of beriberi. *PJS.*, 8B (1913) 175-195.
 18. VEDDER, E. B., and FELICIANO, R. T. An investigation to determine a satisfactory standard for beriberi-preventing rices. *PJS.*, 35 (1928) 351-387.
 19. WELLS, A. H. The preparation of tikitiki extract for the treatment of beriberi. *PJS.*, 19 (1921) 67-73.
 20. WILLIAMS, R. R. Las vitaminas del beriberi desde el punto de vista teorico y experimental. *Rev. Filip. de Med. y Farm.*, 5 (1914) 697-702.
 21. WILLIAMS, R. R., and SALEEBY, N. M. Experimental treatment of human beriberi with constituents of rice polishings. *PJS.*, 10B (1915) 99-119.
 22. WILLIAMS, R. R., and CROWELL, B. C. The thymus gland in beriberi. *PJS.*, 10B (1915) 121-125.
 23. WILLIAMS, R. R., and JOHNSTON, J. A. Miscellaneous notes and comments on beriberi. *PJS.*, 10B (1915) 337-343.
- H. Yaws*
1. ASHBURN, P. M., and CRAIG, C. F. Observation upon *Treponema pertenue* Castellani of yaws and the experimental production of the disease in monkeys. *PJS.*, 2B (1907) 441-465.
 2. BLOOMBERGH, H. S. The Wassermann reaction in syphilis, leprosy, and yaws. *PJS.*, 6B (1911) 335-341.
 3. BOWMAN, F. B. Complement fixation in yaws. *PJS.*, 5B (1910) 485-487.
 4. GARCIA, O. The relation of the Wassermann and the Kahn reactions with regard to *Treponema* antigen. *PJS.*, 40 (1929) 79-87.
 5. GARCIA, O. Serologic study of cerebrospinal fluids in Philippine monkeys inoculated with yaws, syphilis, or both. *PJS.*, 50 (1933) 199-203.
 6. GOODPASTURE, E. W., and DE LEON, W. The effect of treatment on the Wassermann reaction in yaws. *PJS.*, 22 (1923) 221-231.
 7. GOODPASTURE, E. W. The histology of healing yaws. *PJS.*, 22 (1923) 263-283.
 8. LACY, G. R., and SELLARDS, A. W. Investigation of immunity in yaws. *PJS.*, 30 (1926) 453-459.
 9. LOPEZ-RIZAL, L., and SELLARDS, A. W. A clinical modification of yaws observed in patients living in mountainous districts. *PJS.*, 30 (1926) 497-503.
 10. MARSHALL, H. T. Yaws: a histologic study. *PJS.*, 2B (1907) 469-475.
 11. MIYAO, ISAO. Is the Wassermann reaction provoked in the Philippine monkeys by yaws vaccination specific? *PJS.*, 40 (1929) 71-73.
 12. MIYAO, ISAO. Following the subcutaneous immunization with yaws vaccine is the skin tissue proper responsible for the production of Wassermann reagin or do other tissues also participate? *PJS.*, 40 (1929) 75-78.
 13. MIYAO, ISAO. Yaws lesions on mucous membranes and a report of two cases of genital manifestations of framboesia tropica; an instance of genital transmission of yaws. *PJS.*, 41 (1930) 13-21.
 14. MIYAO, ISAO. An unusual late, fungoid, and ulcerative yaws lesion in an experimental monkey. *PJS.*, 41 (1930) 25-27.
 15. MIYAO, ISAO. Note on the viability of *Treponema luisi*. *PJS.*, 42 (1930) 199-201.
 16. MIYAO, ISAO. An inquiry into the so-called latent infection in yaws vaccinated monkeys as a possible result of the test for immunity by intradermal inoculation with living yaws material. *PJS.*, 43 (1930) 425-428.
 17. MIYAO, ISAO. Immunologic relation between three Philippine strains of yaws. *PJS.*, 43 (1930) 429-432.
 18. MIYAO, ISAO. Is framboesia tropica a nosologic entity? *PJS.*, 43 (1930) 433-449.
 19. MIYAO, ISAO. Experimental inquiry into the possibility of transmission of yaws by leeches. *PJS.*, 47 (1932) 463-465.
 20. SCHÖBL, O., SELLARDS, A. W., and LACY, G. R. Some protein manifestations of the skin lesions of yaws. *PJS.*, 30 (1926) 475-481.
 21. SCHÖBL, O., and RAMIREZ, J. The globulin precipitation reaction in yaws; its independence of the Wassermann reaction and its behavior during the course and treatment of the disease. *PJS.*, 30 (1926) 483-496.
 22. SCHÖBL, O. Some factors in treponematous infection that influence the result of the Wassermann reaction. *J. Phil. Is. Med. Assn.*, 7 (1927) 122-125.
 23. SCHÖBL, O. Experimental yaws in Philippine monkeys. *Far. East Assn. Trop. Med. 7th Cong. Tokyo, Trans.*, 2 (1927) 541-543. [Also published in *Rev. Filip. de Med. y Farm.*, 8 (1927) 236-258.]
 24. SCHÖBL, O. Note on local terminology of certain manifestations of yaws. *PJS.*, 35 (1928) 127-132.

25. SCHÖBL, O. Experimental yaws in Philippine monkeys and a critical consideration of our knowledge concerning *framboesia tropica* in the light of recent experimental evidence. *PJS.*, 35 (1928) 209-332.
26. SCHÖBL, O. Immunity in yaws. *J. Philip. Is. Med. Assn.*, 8 (1928) 6-10.
27. SCHÖBL, O. Serologic studies in experimental yaws. *PJS.*, 40 (1929) 53-56.
28. SCHÖBL, O., and TANABE, B. Experiments concerning the yaws antigen which produces positive Wassermann reaction when injected in suitable experimental animals. *PJS.*, 40 (1929) 57-68.
29. SCHÖBL, O. Summary of serologic studies in experimental yaws. *PJS.*, 40 (1929) 89-90.
30. SCHÖBL, O., and MIYAO, ISAO. Immunologic relation between yaws and syphilis. *PJS.*, 40 (1929) 91-108.
31. SCHÖBL, O., and GARCIA, O. Serologic reciprocity between yaws and syphilis. *PJS.*, 42 (1930) 203-214.
32. SCHÖBL, O., TANABE, B., and MIYAO, I. Preventive immunization against treponematous infections and experiments which indicate the possibility of anti-treponematous immunization. *PJS.*, 42 (1930) 219-237.
33. SCHÖBL, O. Experimental study of immunologic reciprocity between yaws and syphilis, considering also other phases of immunity besides the complete resistance to infection. *PJS.*, 42 (1930) 239-250.
34. SCHÖBL, O. Further experiments concerning immunologic reciprocity between yaws and syphilis. *PJS.*, 43 (1930) 263-264.
35. SCHÖBL, O. Immunologic reciprocity between syphilis and yaws. *PJS.*, 43 (1930) 583-588.
36. SCHÖBL, O. The immunologic effect of repeated yaws infections interrupted by specific treatment given in the early stage of initial yaws. *PJS.*, 43 (1930) 589-594.
37. SCHÖBL, O. The duration of anti-treponematous immunity in Philippine monkeys originally conveyed by immunization with killed yaws vaccine. *PJS.*, 43 (1930) 599-601.
38. SCHÖBL, O. The immunologic effect of anti-treponematous vaccine therapy administered after specific treatment which was given in the early stage of initial local yaws in Philippine monkeys. *PJS.*, 43 (1930) 603-607.
39. SCHÖBL, O. An interpretation of the laws of Brown and Pearce that govern the course of treponematoses. *PJS.*, 46 (1931) 169-175.
40. SCHÖBL, O. Coexistent infection with yaws and syphilis. *PJS.*, 46 (1931) 177-181.
41. SCHÖBL, O. The prospects of vaccination and vaccine therapy in treponematoses. *PJS.*, 46 (1931) 183-187.
42. SCHÖBL, O. Further experiments concerning immunity in treponematous infections. *PJS.*, 45 (1931) 221-229.
43. SCHÖBL, O., and HAMELMANN, C. M. über Beziehungen zwischen Fromboesie und Syphilis. *Archiv. für Schiffs- und Tropenhygiene*, 36 (1932) Beiheft 2, 1-36.
44. SELLARDS, A. W., GOODPASTURE, E. W., and DE LEON, W. Mortifications concerning yaws. *PJS.*, 22 (1923) 219-220.
45. SELLARDS, A. W., and GOODPASTURE, E. W. Immunity in yaws. *PJS.*, 22 (1923) 233-247.
46. SELLARDS, A. W. Public health aspects of yaws. *PJS.*, 22 (1923) 251-262.
47. SELLARDS, A. W., and GOODPASTURE, E. W. Summary concerning the control of yaws. *PJS.*, 22 (1923) 285-289.
48. SELLARDS, A. W., LACY, G. R., and SCHÖBL, O. Superinfection in yaws. *PJS.*, 30 (1926) 463-474.
49. STRONG, R. P. The specific cure of yaws with dioxy-diamido-arseno-benzol. *PJS.*, 5B (1910) 433-451.
50. TANABE, B. The effect of the administration of alcohol upon the result of the Wassermann test in yaws-monkeys. *PJS.*, 37 (1928) 247-250.
51. TANABE, B. Note on the duration of immunity to yaws in Philippine monkeys. *PJS.*, 40 (1929) 49-51.
52. WOOLLEY, P. G. V. Framboesia: its occurrence in natives in the Philippine Islands. *Manila, Bur. of Print.* (1904) 51-54. [*Bur. of Govt. Lab. P. I., Pub.*, No. 20, Serum lab.]
53. YASUYAMA, K. Viability of *Treponema pertenue* outside of the body and its significance in the transmission of yaws. *PJS.*, 35 (1928) 333-349.

I. Intestinal parasites

1. BOWMAN, F. B. Observations on parasitic infection among Igorots. *Manila Med. Soc. Bull.*, 2 (1910) 75.
2. CHAMBERLAIN, W. P. A statistical study of uncinariasis among white men in the Philippines. *PJS.*, 5B (1910) 249-266.
3. CHAMBERLAIN, W. P., et al. Examination of stools and blood among the Igorots at Baguio, Philip. Islands. *PJS.*, 5B (1910) 505-514.
4. CROWELL, B. C. Review of the chief intestinal lesions encountered in one thousand consecutive autopsies in Manila. *Asamblea Regional*

- de Médicos y Farmacéuticos de Filipinas, 2d. Actas, Memorias, y Comunicaciones* (1914) 167-174.
5. CROWDER, B. C., and HAMMOCK, R. W. Intestinal parasites encountered in five hundred autopsies, with reports of cases. *PJS.*, 8B (1908) 157-174.
 6. GARCIA, O., VAZQUEZ-COLET A., and LACY, G. R. Bacteriological examination of stools of food handlers in Manila. *PJS.*, 24 (1924) 735-744.
 7. GARRISON, P. E. A preliminary report upon the specific identity of the cestode parasites of man in the Philippine Islands with a description of a new species of *Taenia*. *PJS.*, 2B (1907) 537-550.
 8. GARRISON, P. E. The prevalence and distribution of the animal parasites of man in the Philippine Islands, with a consideration of their possible influence upon the public health. *PJS.*, 3B (1908) 191-209.
 9. GARRISON, P. E. A new intestinal trematode of man. *PJS.*, 3B (1908) 385-393.
 10. GARRISON, P. E., and LLAMAS, R. The intestinal worms of 385 Filipino women and children in Manila. *PJS.*, 4B (1909) 185-186.
 11. GARRISON, P. E., *et al.* Medical survey of the town of Taytay. X. Animal parasites of the intestine. *PJS.*, 4B (1909) 257-269.
 12. GOMEZ, L. A clinical study of hookworm infection in the Philippines. *PJS.*, 6B (1911) 239-249.
 13. HAUGHWOUT, F. G., and HORILLEN, F. S. The intestinal animal parasites found in one hundred sick Filipino children. *PJS.*, 16 (1920) 1-73.
 14. HAUGHWOUT, F. G. A case of human coccidiosis detected in the Philippine Islands, with remarks on the development and vitality of the cysts of *Isospora hominis* (Rivolta). *PJS.*, 18 (1921) 449-482.
 15. LEACH, C. N., SCHWARTZ, B., LEACH, F. D., and HAUGHWOUT, F. G. Hookworm diseases: a clinical entity in the Philippine Islands. *PJS.*, 23 (1923) 105-120.
 16. LEACH, C. N., HAUGHWOUT, F. I., and ASH, J. E. The treatment of hookworm infestation with carbon tetrachloride: a clinical and laboratory study. *PJS.*, 23 (1923) 455-512.
 17. LEFEVRE, M. Researches on ascarids among lepers. *PJS.*, 5B (1910) 463-474.
 18. MUGRAVE, W. E., and CLEGG, M. T. Trichocephaliasis with a report of four cases, including one fatal case. *PJS.*, 3B (1908) 545-566.
 19. RIMLER, R. S., and GOMEZ, L. The prevalence of intestinal parasites in Rizal and Cavite provinces and in Cagayan Valley. *PJS.*, 5B (1910) 267-275.
 20. RUEDIGER, E. H. Some observations on so-called flagellate, ciliate, and other protozoa encountered in water and in human stools. Preliminary report. *PJS.*, 6B (1911) 155-161.
 21. SCHÖBL, O. The etiology of trichomycosis palmellina in the Philippine Islands. *PJS.*, 9B (1914) 219-225.
 22. SELLARDS, A. W. Immunity reactions with amoebae. *PJS.*, 6B (1911) 281-298.
 23. TUBANGUI, M. A. Worm parasites of the brown rat (*Mus norvegicus*) in the Philippine Islands, with special reference to those forms that may be transmitted to human beings. *PJS.*, 46 (1931) 537-591.
 24. VAZQUEZ-COLET, A. The viability of intestinal pathogenic bacteria in fruits and Philippine foods eaten raw. *PJS.*, 24 (1924) 35-39.
 25. WALKER, E. L. The schizogony of *Trypanosoma evansi* in the spleen of the vertebrate host. *PJS.*, 7B (1912) 53-63.
 26. WALKER, E. L. The life history of *Oesophagostomum apistomum*: 1. Development outside of the host. *PJS.*, 8B (1913) 501-507.
 27. WILLETS, D. G. A statistical study of intestinal parasites in tobacco haciendas of the Cagayan Valley, Philippine Islands. *PJS.*, 6B (1911) 77-92.
 28. WILLETS, D. G. Intestinal parasitism, particularly entamoebiasis in patients of the Philippine General Hospital, Manila, P. I. *PJS.*, 9B (1914) 81-92.
 29. WILLETS, D. G. Intestinal helminthiasis in the Philippine Islands as indicated by examination of prisoners upon admission to Bilibid prison, Manila, P. I. *PJS.*, 9B (1914) 233-240.
 30. WOOLEY, P. G., and MUGRAVE, W. E. III. The pathology of intestinal thrombosis Manila, Bur. of Print (1905) 31-48. [*Bur. of Govt. Lab. P. I., Pub., No. 32.*]

J. Dengue

1. ASHBURN, P. M., and CRAIG, C. F. Experimental investigations regarding the etiology of dengue fever with a general consideration of the disease. *PJS.*, 2B (1907) 93-152.
2. HOLT, R. L., and KINTNER, J. H. Notes on dengue. *PJS.*, 46 (1931) 593-598.
3. ST. JOHN, J. H., SIMMONS, J. S., and REYNOLDS, F. H. K. Transmission of the virus of dengue fever from mosquito to mosquito. *PJS.*, 41 (1930) 381-384. [Abstracted in *Am. J. Trop. Med.*, 10 (1930) 23-24.]

4. ST. JOHN, J. H., *et al.* The survival of various microorganisms within the gastro-intestinal tract of *Aedes aegypti*. *Am. J. Trop. Med.*, 10 (1930) 237-241.
5. SILER, J. F., *et al.* Dengue: its history, epidemiology, mechanism of transmission, etiology, clinical manifestations, immunity, and prevention. *Manila*, Bur. of Print. (1926) 476 pp. [*PJS.*, 29 (1926) 1-304. Also *Bur. of Sci., P. I., Monograph*, No. 20.]
6. SIMMONS, J. S., ST. JOHN, J. H., and REYNOLDS, F. H. K. Transmission of dengue fever by *Aedes albopictus* Skuse. *PJS.*, 41 (1930) 215-229. [Also abridged in *Am. J. Trop. Med.*, 10 (1930) 17-21.]
7. SIMMONS, J. S., ST. JOHN, J. H. and REYNOLDS, F. H. K. Experimental studies of dengue. *PJS.*, 44 (1931) 1-251. [Also *Bur. of Sci., P. I., Monograph*, No. 29.]
- TAYTAY. VII. Mosquitoes and other insects. *PJS.*, 4B (1909) 233-239.
9. BANKS, C. S. Four new Culicidae from the Philippines. *PJS.*, 4A (1909) 345-351.
10. BANKS, C. S. The mosquito problem in Manila. *Manila Med. Soc. Bull.*, 2 (1910) 25-26.
11. BANKS, C. S. Community measures against mosquitoes. *Manila Med. Soc. Bull.*, 2 (1910) 316-319.
12. BANKS, C. S. A new Philippine malaria mosquito. *PJS.*, 9D (1914) 405-407.
13. BANKS, C. S. Mosquitoes (In "The Blood Sucking Insects of the Philippines.") *PJS.*, 14 (1919) 174-175.
14. BANKS, C. S. The swarming of anopheline mosquitoes. *PJS.*, 15 (1919) 283-288.
15. BARBER, M. A., *et al.* Malaria in the Philippine Islands. II. The distribution of the common anophelines and the distribution of malaria. *PJS.*, 10B (1915) 177-245.
16. BOWMAN, F. B. The incidence and complications of malaria in the Philippine Islands, with special reference to its treatment with, arsenophenylglycine. *Manila Med. Soc. Bull.*, 5 (1910) 291-302.
17. BOWMAN, F. B. A note on urinary pigment as a diagnostic sign in malaria. *Manila Med. Soc. Bull.*, 3 (1911) 112-113.
18. HOLT, R. L., and RUSSELL, P. F. Spleen survey of the eastern shore of Bataan province, Luzon. *PJS.*, 45 (1931) 211-218.
19. HOLT, R. L. Malarial notes. *Milit. Surg.*, 69 (1931) 450-451.
20. HOLT, R. L. A new mosquito spray. *Milit. Surg.*, 69 (1931) 625-627.
21. HOLT, R. L., and RUSSELL, P. F. Malaria and *Anopheles* reconnaissance in the Philippines. *PJS.*, 49 (1932) 305-371.
22. HOLT, R. L., and KINTNER, J. H. Antimosquito sprays. *PJS.*, 47 (1932) 433-38.
23. KING, W. V. The Philippine varieties of *Anopheles gigas* and *Anopheles lindesayi*. *PJS.*, 46 (1931) 751-756.
24. KING, W. V. The Philippine *Anopheles* of the *rossi-ludlowi* group. *PJS.*, 47 (1932) 305-339.
25. KING, W. V. The Philippine *Anopheles* of the *funestus-minimus* subgroup. *PJS.*, 48 (1932) 485-523.
26. MUGRAVE, W. W., *et al.* Sanitary survey of the San José Estate and adjacent properties in Mindoro Island, P. I., with special reference to the epidemiology of malaria. *PJS.*, 9B (1914) 137-197.
27. NICHOLAS, HENRY J. Medical survey of the town of Taytay. VIII. Filariasis, malaria,

K. Filariasis

1. ASHBURN, P. M., and CRAIG, C. F. Observations upon *Filaria philippinensis* and its development in the mosquito. *PJS.*, 2B (1907) 1-14.
2. PHALEN, J. M., and NICHOLS, H. J. Filariasis and elephantiasis in southern Luzon. *PJS.*, 3B (1908) 293-303.
3. PHALEN, J. M., and NICHOLS, H. J. Notes on the distribution of *Filaria nocturna* in the Philippine Islands. *PJS.*, 3B (1908) 305-309.
4. PHALEN, J. M., and NICHOLS, H. J. The distribution of *Filaria* in the Philippine Islands. *PJS.*, 4B (1909) 127-139.

L. Malaria

1. ASHBURN, P. M., *et al.* A spirillum in the blood of a case of black-water fever. *Manila Med. Soc. Bull.*, 4 (1912) 198.
2. BANKS, C. S. A new genus and species of Culicidae. *PJS.*, 1 (1906) 779-783.
3. BANKS, C. S. A list of Philippine Culicidae with descriptions of some new species. *PJS.*, 1 (1906) 977-1005.
4. BANKS, C. S. Problems in economic entomology in the Philippines. *PJS.*, 1 (1906) 1067-1074. [Mosquitoes, pp. 1072-1073.]
5. BANKS, C. S. Experiments in malarial transmission by means of *Myzomyia ludlowi* Theob. *PJS.*, 2B (1907) 513-535.
6. BANKS, C. S. Biology of Philippine Culicidae. *PJS.*, 3A (1908) 235-258.
7. BANKS, C. S. A mosquito which breeds in salt and fresh water. *PJS.*, 3B (1908) 335-341.
8. BANKS, C. S. Medical survey of the town of

- tuberculosis, typhoid fever, goitre, beriberi, venereal and skin diseases *PJS*, 4B (1909) 279-286
28. NOMO, A. M. Avian malaria studies VI Susceptibility of *Lutzia fuscata* (Wiedemann) Edwards to avian malaria *PJS*, 49 (1932) 225-228.
 29. RUSSELL, P F *Anopheles* mosquitoes and avian malaria. *Am J Trop Med*, 11 (1931) 145-146
 30. RUSSELL, P F A method of feeding blood meals to mosquitoes in male and female Preliminary note *Am J Trop Med*, 11 (1931) 355-358
 31. RUSSELL, P F Dental instruments for mosquito dissection *Am J Trop Med*, 11 (1931) 359-360
 32. RUSSELL, P F Malaria, an account of its cause, cure, and prevention *Manila, Bur of Print* (1931) 62 pp [*Bur of Sci*, P I, *Popular Bull.*, No 10]
 33. RUSSELL, P F Plasmodium simplex, a prophylactic drug in avian malaria *Am J Trop Med*, 11 (1931) 279-284
 34. RUSSELL, P F Avian malaria studies I Prophylactic plasmodium in inoculated avian malaria *PJS*, 46 (1931) 305-345
 35. RUSSELL, P F Avian malaria studies II Prophylactic plasmodium versus prophylactic quinine in inoculated avian malaria *PJS*, 46 (1931) 347-367
 36. RUSSELL, P F Avian malaria studies III The experimental epidemiology of avian malaria introductory paper *PJS*, 46 (1931) 651-677
 37. RUSSELL, P F Daytime resting places of *Anopheles* mosquitoes in the Philippines First report *PJS*, 46 (1931) 639-648
 38. RUSSELL, P F The control of *Anopheles minimus* mosquito larvae in the Philippines by stranding and flushing First report *PJS*, 47 (1932) 439-445
 39. RUSSELL, P F, and WEST, A P Charcoal as a diluent for Paris green in the destruction of *Anopheles* larvae Larvicide studies I *PJS*, 48 (1932) 291-297
 40. RUSSELL, P F, and WEST, A P Some studies in the larvicidal effects of arsenicals other than Paris green against *Anopheles* larvae Larvicide studies III *PJS*, 49 (1932) 97-103
 41. RUSSELL, P F, and WEST, A P The effect on *Culex* larvae of Paris green diluted with charcoal, and notes on the feeding habits of *Culex quinquefasciatus* Larvicide studies V *PJS*, 49 (1932) 651-674
 42. RUSSELL, P F Avian malaria studies IV *Haemaphysalis* and *Plasmodium* in birds of Luzon, Philippine Islands *PJS*, 48 (1932) 263-268
 43. RUSSELL, P F Avian malaria studies V *Plasmodium capistrans*, sp nov, an avian malaria parasite in the Philippines *PJS*, 48 (1932) 269-287
 44. RUSSELL, P F, and NOMO, A M Avian malaria studies VII Plasmodium as a prophylactic drug in sporozoite infections of avian malaria *PJS*, 49 (1932) 595-623
 45. RUSSELL, P F Avian malaria studies VIII The bleeding time in canaries, normal and in malaria *PJS*, 49 (1932) 627-647
 46. RUSSELL, P F Daytime resting places of *Anopheles* mosquitoes in the Philippines Second report *Proc Entom Soc Wash*, 34 (1932) 129-138
 47. RUSSELL, P F, and SANTIAGO, D *Anopheles minimus* larvae from wells in Laguna Province, Philippine Islands *PJS*, 49 (1932) 219-222
 48. RUSSELL, P F, and HOLT, R L Malaria prophylaxis with chinoplasmin a field experiment *Am J Trop Med*, 12 (1932) 369-379
 49. RUSSELL, P F Automatic distribution of Paris green for malaria control *J Parasitol*, 19 (1933) 215-224
 50. RUSSELL, P F Malaria in the Philippine Islands *Am J Trop Med*, 12 (1933) 167-178
 51. RUSSELL, PAUL F Lectures on malaria prophylaxis and mosquito control *J Philip Is Med Assn*, 13 (1933) 277-288, 339-351, 381-391
 52. SIMMONS, J S Malaria on the island of Corregidor, P I II Report of a survey for anopheline mosquitoes made Dec 1928 *Milit Surg*, 64 (1929) 909-911
 53. SIMMONS, J S, and ST JOHN, J H The prevalence and distribution of malaria on the island of Corregidor, P I *Milit Surg*, 64 (1929) 710-733
 54. SIMMONS, J S, ST JOHN, J H, and REYNOLDS, F H K A malaria survey at Fort Stotsenburg, P I *Milit Surg*, 67 (1930) 1-13
 55. TIEDERMANN, W V D Malaria in the Philippines *J Prev Med*, 1 (1927) 205-254
 56. WALKER, E L, and BARBER, M A Malaria in the Philippine Islands *PJS*, 9B (1914) 381-439
 57. WEST, A P, and RUSSELL, P F Paris green partially adsorbed on charcoal as a larvicide for *Anopheles* mosquitoes *PJS*, 48 (1932) 545-561
 58. WEST, A P, and RUSSELL, P F Experiments with various toxic substances partially adsorbed on charcoal as an *Anopheles* larvicide

Larvicide studies IV. *PJS.*, 49 (1932) 211-217.

59. WILLETT, D. G. Malaria in the Philippine General Hospital, Manila, P. I. during the fiscal year 1913. *PJS.*, 9B (1914) 441-452.

M. Smallpox

1. ASHBURN, P. M., *et al.* The relationship of variola and vaccinia. *PJS.*, 8B (1913) 17-28.
2. ASHBURN, P. M., *et al.* Concerning varioloids in Manila. *PJS.*, 8B (1913) 403-404.
3. BRINCKERHOFF, W. R., and TYZZER, E. E. Studies upon experimental variola and vaccinia in *Quadrumania*. *PJS.*, 1 (1906) 239-347.
4. RUDIGER, E. H. The preservation of vaccine virus. *Manila Med. Soc. Bull.*, 2 (1910) 221-222.
5. SCHÖBL, O. Note on the keeping qualities of dried and pulverized vaccine virus. *PJS.*, 17 (1920) 55-57.
6. SCHÖBL, O. Resumen de nuestro conocimiento actual sobre la vacunación contra la viruela. *Rev. Filip. de Med. y Farm.*, 11 (1920) 425-445.
7. TYZZER, E. E. The histology of the skin lesions in varicella. *PJS.*, 1 (1906) 349-372.
8. WOOLLEY, P. G. Vaccine virus: method of preparation at the government laboratory. *Bur. of Sci. Amer. Dept.*, 1-3 (1902-4) 1-7.

N. Tuberculosis

1. BARBER, M. A. I. Experiments on the immunization of guinea pigs by the inoculation of avirulent tubercle bacilli in agar. II. Observations on animals inoculated with tuberculosis from lepers. *PJS.*, 10B (1915) 145-161.
2. CROWELL, B. C. Addison's disease and adrenal tuberculosis. *PJS.*, 6B (1911) 345-359.
3. SCHÖBL, O. Summary of the pathogenesis of experimental pneumococcus pneumonia. *Far East Assn. Trop. Med. Tokyo. 6th Cong. Trans.*, 2 (1925) 745-748.
4. SCHÖBL, O., and SELLARDS, A. W. Experimental pneumonia in monkeys. *PJS.*, 31 (1926) 1-29.
5. WHITMORE, E. R. Tuberculosis in the Philippine Islands. *PJS.*, 4B (1909) 453-460.
6. WHITMORE, E. R. Tuberculosis in the Philippines: Final result of one year's specific treatment of eighty cases of pulmonary tuberculosis. *PJS.*, 5B (1910) 563-564.

O. Food and nutrition

1. AGCAOILI, F. The composition of various milks and their adaptability for infant feeding. *PJS.*, 8A (1913) 141-149. [Spanish transla-

tion in *Rev. Filip. de Med. y Farm.*, 3 (1914) 12-24.]

2. AGCAOILI, F. A discussion of the vegetables of the Philippine Islands. *Asamblea Regional de Medicos y Farmaceuticos de Filipinas, 3rd. Actas, Memorias, y Comunicaciones*, (1917) 579-580.
3. AGCAOILI, F. Consideration on the proper diet. *Census of the Philippine Islands, 1903* 917-27.
4. BARBER, M. A. Milk poisoning due to a type of *Staphylococcus albus* occurring in the udder of a healthy cow. *PJS.*, 9B (1914) 345-349.
5. BRILL, H. C. The antineuritic properties of the infusorial earth extract of the hydrolyzed extract of rice polishings. *PJS.*, 22A (1917) 199-206.
6. BRILL, H. C. Food and drug inspection in the Philippine Islands. *Asamblea Regional de Medicos y Farmaceuticos de Filipinas, 3rd. Actas, Memorias, y Comunicaciones* (1917) 333-335.
7. BRILL, R. C. The ferric chloride test for salicylic acid in foods. *Asamblea Regional de Medicos y Farmaceuticos de Filipinas, 3rd. Actas, Memorias, y Comunicaciones*, (1917) 554-55. [In Spanish, pp. 556-57.]
8. FITZBUTLER, J. H. The municipal milk supply and suggestions for its betterment. *Manila Med. Soc. Bull.*, 3 (1911) 116-122.
9. HERMANO, A. J. Biological study on the nutritive value of rice protein from different varieties (abstract). *U. P. Natural and Applied Sc. Bull.*, 2 (1932) 234.
10. HERMANO, A. J. The vitamin contents of certain Philippine foods. *Philippine Health Service, Monthly Bull.*, 10 (1930) 231-232.
11. HERMANO, A. J. Food values. *Bur. Sci., P. I., Popular Bull.*, No. 16 (1932) 56, 75.
12. HERMANO, A. J., and ANIDO, F. The chemical and biological analysis of tiki-tiki extracts (abstract). *U. P. Natural and Applied Sci. Bull.*, 2 (1932), 223-224.
13. MERRILL, E. D. Medical survey of the town of Taytay. V. The principal foods utilized by the natives. *PJS.*, 4B (1909) 219-223.
14. MURGRAVE, W. E., and RICHMOND, G. R. Infant feeding and its influence upon infant mortality in the Philippine Islands. *PJS.*, 2B (1907) 361-385.
15. MURGRAVE, W. E. Infant feeding in the Philippines. *Asamblea Regional de Medicos y Farmaceuticos de Filipinas, 1st. Memorias y Comunicaciones*, (1912) 402-404.
16. OROSA, MARIA Y. Preservation of Philippine foods. *Bur. Sci., P. I., Popular Bull.*, No. 2.

17. OROSA, MARIA Y. Recipes for sea food, with an introduction by Wallace Adams. *Bur. Sci., P. I., Popular Bull.*, No. 8.
 18. OROSA, MARIA Y. Soy beans as a component of a balanced diet and how to prepare them. *Bur. Sci., P. I., Popular Bull.*, No. 13.
 19. OROSA, MARIA Y. Roselle recipes. *Bur. Sci., P. I., Popular Bull.*, No. 14.
 20. OROSA, MARIA Y. Rice bran: a health food and how to cook it. *Bur. Sci., P. I., Popular Bull.*, No. 15.
 21. OROSA, MARIA Y. The possibilities of darak (rice bran) in the diet of the Filipinos (Abstract). *U. P. Natural and Applied Sci. Bull.*, 2 (1932) 256-257.
 22. OROSA, MARIA Y. Soy beans as food (abstract). *U. P. Natural and Applied Sci. Bull.*, 2 (1932) 257.
 23. SALVADOR, WENCESLAW. The food value of Philippine bananas. *Philip. Pharm. Assn. Proceedings 1st.*, (1921) 71-91.
 24. SEALE, ALVIN. Fish as a food supply of the sea harvest. *Asamblea Regional de Medicos y Farmaceuticos de Filipinas*, 3rd. *Actas, Memorias y Comunicaciones*, (1917) 336-38.
 25. WILLIAMS, R. R. Las vitaminas del beriberi desde el punto de vista teorico y experimental. *Rev. Filip. de Med. y Farm.*, 5 (1914) 697-702.
 26. WILLIAMS, R. R. The chemistry of the vitamins. *PJS.*, 11A (1916) 49-57.
- P. Water supplies*
1. AGUILAR, R. H. Relative radioactivity of deep-well waters in Manila and vicinity. *PJS.*, 45 (1931) 183-199.
 2. ADAMS, B. I. Medical survey of the town of Taytay. II. Geology and water supply. *PJS.*, 4B (1909) 211-214.
 3. BARBER, M. A. A bacteriological examination of certain artesian wells in Rizal, Cavite, and Bulacan provinces, P. I. *PJS.*, 8 (1913) 443-458.
 4. CLEGG, M. T. Medical survey of the town of Taytay. III. Bacteriological analysis of the water supply. *PJS.*, 4B (1909) 215-216.
 5. COX, A. J., et al. Water supplies in the Philippine Islands. *PJS.*, 9A (1914) 273-411; 10A (1915) 135-169.
 6. EDWARDS, R. T. A biological study of the water supply of the Philippine Islands, with a description of a new pathogenic organism. *PJS.*, 3B (1908) 121-130.
 7. FAUSTINO, L. A., et al. Manila water supply. *Manila*, Bur. of Print. (1931). [*Bur. of Sci., P. I., Popular Bull.*, No. 9.]
 8. GABEL, C. E. Bacteriological examinations of swimming pools in Manila. *PJS.*, 11B (1916) 63-84. [Abstract in *Asamblea Regional de Med. y Farm. de Filipinas*, 3rd. *Actas, Memorias y Comunicaciones*, (1917) 343-346. Spanish translation: 339-342. Also abstracted in *Rev. Filip. de Med. y Farm.*, 7 (1916) 403-408.]
 9. GOMEZ, L. La biologia de las aguas potables de las Islas Filipinas. *Asamblea Regional de Medicos y Farmaceuticos de Filipinas*, 1st. *Memorias y Comunicaciones*, (1912) 480-487. [Also published in *Rev. Filip. de Med. y Farm.*, 3 (1913) 73-81.]
 10. HEISE, G. W. Analisis del agua en el campo. *Asamblea Regional de Medicos y Farmaceuticos de Filipinas*, 3d. *Actas, Memorias, y Comunicaciones*, (1917) 529-533.
 11. HEISE, G. W. Water supply of the city of Iloilo. *PJS.*, 10A (1915) 65-73. [Spanish translation in *Asamblea Regional de Medicos y Farmaceuticos de Filipinas*, 3rd. *Actas, Memorias, y Comunicaciones*, (1917) 525-528. Also in *Rev. Filip. de Med. y Farm.*, 17 (1916) 618-621.]
 12. HEISE, G. W. The radioactivity of the waters of the mountainous region of Northern Luzon. *PJS.*, 12A (1917) 293-307.
 13. HEISE, G. W. The constancy in the radioactivity of certain Philippine waters. *PJS.*, 12A (1917) 309-311.
 14. HEISE, G. W. Analisis del agua en el campo. *Asamblea Regional de Medicos y Farmaceuticos de Filipinas*, 3d. *Actas, Memorias, y Comunicaciones*, (1917) 529-533.
 15. HEISE, G. W. Notes on the water supply of the city of Manila. *PJS.*, 11A (1916) 1-13. [Spanish translation in *Asamblea Regional de Medicos y Farmaceuticos de Filipinas*, 3d. *Actas, Memorias, y Comunicaciones*, (1917) 534-541.]
 16. HEISE, G. W., and AGUILAR, R. H. The chemical purification of swimming pools. *PJS.*, 11A (1916) 105-123. [Spanish translation in *Asamblea Regional de Medicos y Farmaceuticos de Filipinas*, 3d. *Actas, Memorias, y Comunicaciones*, (1917) 542-550.]
 17. HEISE, G. W. Normas analiticas para las aguas de las Islas Filipinas. *Asamblea Regional de Medicos y Farmaceuticos de Filipinas*, 3d. *Actas, Memorias, y Comunicaciones*, (1917) 558-563.
 18. HEISE, G. W. El uso del radio en la profesion medica, y la radioactividad de las aguas de Filipinas. *Rev. Filip. de Med. y Farm.*, 8 (1917) 169-175.

19. RICHMOND, G. F., and GANA, V. Q. Medical survey of the town of Taytay. IV. Chemical analyses of the Taytay waters. *PJS.*, 4B (1909) 217-218.
20. WRIGHT, J. R., and HEISE, G. W. The radioactivity of Philippine waters. *PJS.*, 12A (1917) 145-165.

Q. Miscellaneous

1. BACON, R. F. The physiologically active constituents of certain Philippine medical plants. *PJS.*, 1 (1906) 1007-1036.
2. BACON, R. F., and MARSHALL, H. T. The toxic action of saponin. *PJS.*, 1 (1906) 1037-1042.
3. BACON, R. F. On a rapid clinical method for determining the ammonia coefficient of urines. *PJS.*, 4A (1909) 153-162.
4. BACON, RAYMOND F. Some Philippine medicinal plants. *Manila Med. Soc. Bull.*, 2 (1910) 53-54.
5. BACON, R. F. A preliminary study of the effect of tropical sunlight on the atmosphere, with some notes on radioactive phenomena in the Philippines. *PJS.*, 5A (1910) 267-280.
6. BARBER, M. A. An unusual disease prevailing in epidemic form at Buhí, Ambos Camarines, P. I. *PJS.*, 8B (1913) 369-372.
7. BARBER, M. A. The infection of *Achlya* with various microorganisms. *PJS.*, 8B (1913) 373-383.
8. BARBER, M. A. The pipette method in the isolation of single micro-organisms and in the inoculation of substances into living cells; with a technique for dissection, staining, and other purposes carried out under the higher powers of the microscope. *PJS.*, 9B (1914) 307-360.
9. BOWMAN, F. B. Two cases of *Balanitidum coli* infection, with autopsy. *PJS.*, 4B (1909) 417-423.
10. BOWMAN, F. B. Poisoning from *Datura alba* seeds. *Manila Med. Soc. Bull.*, 3 (1911) 2-3.
11. BROWN, W. H. Official medicinal plants. In his *Minor Products of the Philippine Forests*, 3 (1921) *Bur. of Forestry Bull.*, No. 22.
12. CHAMBERLAIN, W. P. Priority in the demonstration of the Negri bodies in the Philippines. *Manila Med. Soc. Bull.*, 2 (1910) 314-315.
13. CHAMBERLAIN, W. P. Typhoid fever in the Philippine Islands. *PJS.*, 6B (1911) 299-333.
14. CHAMBERLAIN, W. P., and VEDDER, E. B. A Study of Arneith's number classification of the neutrophils in healthy adult males and the influence thereon of race complexion, and tropical residence. *PJS.*, 6B (1911) 405-419.
15. CHAMBERLAIN, W. P., and VEDDER, E. B. The so-called X-bodies as artefacts in glass slides. *PJS.*, 6B (1911) 421-425.
16. CHAMBERLAIN, W. P. Observations on the influence of the Philippine climate on white men of the blond and of the brunette type. *PJS.*, 6B (1911) 427-465.
17. CHAMBERLAIN, W. P. A study of the systolic blood-pressure and the pulse rate of healthy adult males in the Philippines. *PJS.*, 6B (1911) 467-482.
18. CHAMBERLAIN, W. P. The red blood corpuscles and the haemoglobin of healthy adult American males residing in the Philippines. *PJS.*, 6B (1911) 483-488.
19. CHAMBERLAIN, W. P. The occurrence in the Philippines of associated spirochaete and fusiform bacilli in ulcers of the throat (Vincent's angina), of the mouth and of the skin, and in lesions of the lungs (Bronchial spirochaetosis). *PJS.*, 6B (1911) 489-499.
20. CHAMBERLAIN, W. P., et al. Additional discussion of the circular letter: The United States Army Board for the Study of Tropical Diseases in the Philippine Islands. *Manila Med. Soc. Bull.*, 4 (1912) 115-117.
21. COCA, A. F. The bactericidal substances in fibrin. *PJS.*, 4B (1909) 171-175.
22. COCA, A. F., and GILMAN, P. K. The specific treatment of carcinoma. *PJS.*, 4B (1909) 391-402.
23. CROWELL, B. C. Mucocoele and diverticulum of the vermiform appendix of inflammatory origin. *PJS.*, 7B (1912) 29-37.
24. CROWELL, B. C. Status thymico-lymphaticus among Filipinos. *PJS.*, 8B (1913) 77-89.
25. CROWELL, B. C. The chief intestinal lesions encountered in one thousand consecutive autopsies in Manila. *PJS.*, 9B (1914) 453-460.
26. FLEMING, W. D. Solar ultraviolet radiometry I. The ultraviolet limit of sunlight. *PJS.*, 50 (1932) 185-188.
27. FLEMING, W. D. Solar ultraviolet radiometry II. Instruments and methods. *PJS.*, 50 (1932) 279-299.
28. FREER, P. C. The tropical sunlight. *PJS.*, 5B (1910) 1-19.
29. FREER, P. C. The result of the past two years' work in the study of tropical sunlight. *PJS.*, 7B (1912) 1-28.
30. GARCIA, O. A pleomorphic and gas-forming bipolar bacillus isolated from the lymph glands of slaughtered cattle. *PJS.*, 33 (1927) 331-345.

31. GARCIA, O. The relation of the Wassermann and the Kahn reactions with regard to *Treponema* antigen. *PJS.*, 40 (1929) 79-83.
32. GARRISON, P. E., and LEYNER, R. The development of the miracidium of *Paragonimus* under various physical conditions. *PJS.*, 4 (1929) 177-183.
33. GARRISON, P. G. Medical survey of the town of Taytay. XIV. The disposal of human excreta. *PJS.*, 4B (1909) 287-288.
34. GARRISON, P. G. *Davainia madagascariensis* (Davaïne) in the Philippine Islands. *PJS.*, 6B (1911) 165-175.
35. GIBBS, H. D. A study of the effect of tropical sunlight upon men, monkeys, and rabbits, and a discussion of the proper clothing for the tropical climate. *PJS.*, 7B (1912) 91-113.
36. GIBBS, H. D., and AGCAOILI, F. Drug inspection in the Philippine Islands. *Asamblea Regional de Medicos y Farmaceuticos de Filipinas, 2d. Actas, Memorias, y Comunicaciones*, (1914) 633-639.
37. GILMAN, P. K., and CROWELL, B. C. Report of the pathological examinations for one year from the surgical clinic of the Philippine General Hospital. *PJS.*, 7B (1912) 463-467.
38. GOMEZ, L. P. Serology of syphilis. *Rev. Filip. de Med. y Farm.*, 3 (1912) 1-2.
39. GOMEZ, L., KAPANAN, A. M., and GAVINO, C. Diphtheria in the Philippine Islands. *PJS.*, 17 (1920) 37-46.
40. GOMEZ, L., NAVARRO, R., and KAPANAN, A. M. The Schick reaction in Filipinos. *PJS.*, 22 (1922) 323-327.
41. GUERRERO, LEON MARIA. Medicinal uses of Philippine plants. [In Brown's *Minor Products of Philippine Forests*, 3 (1921) 149-246. *Bur. of Forestry Bull.*]
42. HAUGHWOUT, F. G., DOMINGO, E., and DE LEON, W. II. Treatment of a case of acute balantidiosis; recovery; death from other causes; failure to find the parasites in the bowel lumen and gut wall at autopsy. *PJS.*, 16 (1920) 633-646.
43. HAUGHWOUT, F. G. Some less familiar aspects of parasitology. *J. Philip. Is. Med. Assn.*, 1 (1921) 93-99.
44. HAUGHWOUT, F. G. Woodward's monograph on the alvine fluxes: a forgotten classic in the American literature of tropical medicine. *J. Philip. Is. Med. Assn.*, 6 (1926) 218-223.
45. HERZOG, M. A fatal infection by a hitherto undescribed chromogenic bacterium: *Bacillus aureus foetidus*. Manila, Bur. of Print. (1904). [*Bur. Govt. Lab. Pub.*, No. 13.]
46. HERZOG, M. Peculiar cases of traumatism of internal organs, some due to tropical conditions and practices. *PJS.*, 3B (1908) 55-61.
47. HIRANO, H. A study on a Philippine strain of *Leptospira icterohaemorrhagiae*. *PJS.*, 48 (1932) 103-112.
48. HIRANO, H. Blood groups in Philippine monkeys. *PJS.*, 47 (1932) 449-462.
49. LACY, G. R. and GARCIA, O. Results of blood cultures during the recent typhoid investigation in Manila. *J. Philip. Is. Med. Assn.*, 5 (1925) 83-85.
50. McDILL, J. R., and WHERRY, W. B. A report on two cases of a peculiar form of hand infection, due to an organism resembling the Koch-Weeks bacillus. Manila, Bur. of Print. (1904). [*Bur. Govt. Lab. Pub.*, No. 10.]
51. MCKINLEY, E. B. Filterable virus and *Rickettsia* diseases. *PJS.*, 39 (1929) 1-416. [Also *Bur. of Sci. Monographs*, No. 27.]
52. MARSHALL, H. T., and EDWARDS, R. T. Agnesis of the vermiform appendix. *PJS.*, 1 (1906) 1061-1065.
53. MARSHALL, H. T. The recent trend of immunity research. *PJS.*, 2B (1907) 343-360.
54. MARSHALL, H. T., and TRAGUE, O. A study of the precipitin and complement fixation reactions. *PJS.*, 3B (1908) 357-377.
55. MERRILL, E. D. Investigation of the medicinal plants of the Philippines. *Asamblea Regional de Medicos y Farmaceuticos de Filipinas, 3d. Actas, Memorias, y Comunicaciones*, (1917) 569-576.
56. MONTERRAT, C. Comparative study on natural hemolysins in inactivated human and monkey's serum. *PJS.*, 13B (1918) 159-161.
57. MONTERRAT, C. Consideraciones sobre la reaccion de Wassermann: empleo del autoceptor hemolitico antimono. *Rev. Filip. de Med. y Farm.*, 10 (1919) 1-20. *Asamblea Regional de Medicos y Farmaceuticos de Filipinas, 4th. Actas, Memorias, y Comunicaciones*, (1918) 161-171.
58. MUSGRAVE, W. E. The influence of symbiosis upon the pathogenicity of microorganisms (The evolution of parasitism). *PJS.*, 3B (1908) 77-88.
59. MUSGRAVE, W. E. Paragonimiasis in the Philippine Islands. *PJS.*, 2B (1907) 15-65.
60. MUSGRAVE, W. E., and MARSHALL, H. T. Gangosa in the Philippine Islands. *PJS.*, 2B (1907) 387-401.
61. MUSGRAVE, W. E., and CLEGG, M. T. The etiology of mycetoma. *PJS.*, 2B (1907) 477-511.

62. MUGRAVE, W E, and CLEGG, M T. Streptothricosis with special reference to the etiology and classification of mycetoma *PJS*, 3B (1908) 447-544
63. OHNO, Y K. An investigation of the qualitative relationships between agglutinin, agglutinoid, and agglutinable substance *PJS*, 3B (1908) 47-54
64. PHALEN, J M, and NICHOLS, H J. Notes on the condition of the liver in schistosomiasis *PJS*, 3B (1908) 223-229
65. PHALEN, J M, and NICHOLS, H J. Blastomycosis of the skin in the Philippine Islands *PJS*, 3B (1908) 395-405
66. PHALEN, JAMES M. An experiment with orange-red underwear *PJS*, 5 (1910) 525-546
67. PRATT, D S. The optical efficiency of tinted glasses in relieving eye strain *PJS*, 8A (1913) 193-197
68. ROBINSON, C B. Philippine contact poisonous plants *Mansla Med Soc Bull*, 2 (1910) 207-211, 3 (1911) 5-6
69. RUEDIGER, E H. Filtration of immune serums *PJS*, 4B (1909) 333-340
70. RUEDIGER, E H. Rabies in the Philippine Islands and a method available for controlling it *Mansla Med Soc Bull*, 3 (1911) 64-70
71. RUEDIGER, E H. The duration of passive immunity with special reference to that against tetanus *Mansla Med Soc Bull*, 3 (1911) 83-85, 98-102
72. RUEDIGER, E H. The duration of passive immunity against tetanus toxin *PJS*, 8B (1913) 139-142
73. RUEDIGER, E H. The germicidal power of glycerin in various microorganisms under various conditions *PJS*, 9B (1914) 465-477
74. RUEDIGER, E H. The occurrence of *Bacillus coli communis* in the peripheral blood of man during life *PJS*, 10B (1915) 25-28
75. RUEDIGER, E H. The preparation of tetanus antitoxin *PJS*, 10B (1915) 31-61
76. RUEDIGER, E H. Preservation of human serum for Wassermann reaction *PJS*, 11B (1916) 1-17
77. RUEDIGER, E H. Haemolysis by human serum *PJS*, 11B (1916) 33-49
78. RUEDIGER, E H. Wassermann reaction with glycerinated human serum *PJS*, 11B (1916) 87-104
79. RUSSELL, P F. Preventive medicine in retrospect *J Philap Is Med Assn*, 11 (1931) 127-145, 177-198, 297-318, 345-360 12 (1932) 25-30
80. SCHOBEL, O, and MONSERRAT, C. Substitution of human blood cells by monkeys' red corpuscles in performing the complement fixation test for syphilis *PJS*, 12B (1917) 249-253
81. SCHOBEL, O. Medical impressions from abroad *J Philap Is Med Assn*, 3 (1923) 15-17
82. SCHOBEL, O. Semiselective antiseptic effect of the vapors of vegetable oils, essential oils, their constituents, and similar compounds *PJS*, 26 (1925) 501-504
83. SCHOBEL, O. The duration of antitreponematous immunity with regard to syphilis in Philippine monkeys *PJS*, 43 (1930) 595-598
84. SHATTUCK, G C. Notes on chronic ulcers occurring in the Philippines *PJS*, 2B (1907) 551-563
85. STRONG, R P. Para-colon bacillus *Johns Hopkins Hospital Bull*, 13 (1902) 107
86. STRONG, R P. The Panama Canal and its relation to the introduction of yellow fever into our eastern American possessions [*Bur of Sci*, P I, *Ann Rept*, 1-3 (1902-4) 586-88]
87. STRONG, R P. Some questions relating to the evidence of micro-organisms with particular reference to their immunizing powers *Mansla*, Bur of Print (1904) [*Bur Govt Lab*, P I, Pub, No 21]
88. STRONG, R P. The clinical and pathological significance of *Balantidium coli* *Mansla*, Bur of Print (1904) [*Bur of Govt Lab*, P I, Pub, No 26]
89. STRONG, R P. A study of some tropical ulcerations of the skin with particular reference to their etiology *PJS*, 1 (1906) 91-115
90. STRONG, R P. Relation of the Indian form of relapsing fever to African tick fever *PJS*, 4B (1909) 187-193
91. STRONG, R P. Medical survey of the town of Taytay XV Summary and conclusion *PJS*, 5B (1909) 294
92. VAZQUEZ-COLET, A. Rat-bite fever in the Philippines *PJS*, 46 (1931) 159-165
93. WADE, H W. Carbohydrate fermentation by *Bacillus pestis*, comparing certain American and Oriental strains, with analysis of discrepancies of fermentations with Hiss's serum water, litmus agar, and bouillon *PJS*, 11B (1916) 159-182
94. WADE, H W. Studies on cryptoplasmic infection I Development of a *Cryptococcus* in cultures from an unclassified chronic Philippine ulcer *PJS*, 13B (1918) 165-189
95. WADE, H W. Note on the portal of entry in experimental chronic pulmonary (systemic) blastomycosis *PJS*, 13B (1918) 271-274

96. WALKER, E. L. Experimental balantidiosis. *PJS.*, 8B (1913) 333-349.
97. WALKER, E. L. Qualitative determination of the balantidicidal activity of certain drugs and chemicals as a basis for treatment of infections with *Balantidium coli*. *PJS.*, 8B (1913) 1-15.
98. WALKER, E. L. The morphology of the adults of the *Filaria* found in the Philippine Islands. *PJS.*, 9B (1914) 483-491.
99. WHERRY, W. B. Report on an organism resembling the Koch-Weeks bacillus isolated from two cases of a peculiar form of hand infection. *Bur. Sci., P. I., Annual Rept.*, 1-3 (1902-4) 582-586.
100. WHERRY, W. B., and McDILL, J. R. L. Notes on a case of haematochyluria, together with some observations on the morphology of the embryo hematode. *Manila*, Bur. of Print. (1905). [*Bur. Govt. Lab., P. I., Pub.*, No. 31.]
101. WHITMORE, E. R. Medical notes from French Indo-China. *Manila Med. Soc. Bull.*, 2 (1910) 294-296.
102. WHITMORE, E. R. Further observations on therapeutic inoculations of bacterial vaccines. *PJS.*, 5B (1910) 565-568.
103. WILLETS, D. G. A general discussion of pelagra, with report of a probable case in the Philippine Islands. *PJS.*, 5B (1910) 489-503.
104. WILLETS, D. G. General conditions affecting the public health and diseases prevalent in the Batanes Islands, P.I., *PJS.*, 8B (1913) 49-57.
105. WILLETS, D. G., and SCHÖBL, O. Isolation of *Diplococcus intracellularis meningitidis* Weichselbaum from a case of cerebrospinal meningitis occurring in a native of the Philippine Islands. *PJS.*, 8B (1913) 133-138.
106. WILLETS, D. G. Widal reactions among healthy adult Filipinos. *PJS.*, 9B (1914) 253-257.
107. WOOLLEY, P. G. Report on *Bacillus violaceus* Manila: a pathogenic micro-organism. Manila, Bur. of Print. (1904). [*Bur. Govt. Lab., P.I., Pub.*, No. 15.]
108. WOOLLEY, P. G. III. Report on Pinto (Paño Blanco). *Manila*, Bur. of Print. (1904) 35-49. [*Bur. Govt. Lab., P.I., Pub.*, No. 20.]
109. WOOLLEY, P. G. The occurrence of *Schistosoma japonicum velcattoi* in the Philippine Islands. *PJS.*, 1 (1906) 83-90.
110. WOOLLEY, P. G. Tropical febrile splenomegaly. *PJS.*, 1 (1906) 533-539.
111. YASUYAMA, K. Some factors influencing, *in vivo*, the result of the globulin precipitation test. *PJS.*, 31 (1926) 431-439.
112. YASUYAMA, K., and SCHÖBL, O. Free toxin in the blood during the course of tetanus toxæmia. *PJS.*, 32 (1927) 29-34.





THE FIRST MAMMALS

By GEORGE GAYLORD SIMPSON

THE Cenozoic Era, or sometimes more narrowly the Tertiary Period, of the geologists is popularly known as the Age of Mammals. The name is apt, but it may be misleading. Mammals did not arise at the beginning of this Age of Mammals. Recent estimates would place the latter date at about 60,000,000 years ago, and would give at least 180,000,000 years for the present age of the Class Mammalia. Whatever the value of the exact figures, it is unquestioned that the entire Age of Mammals includes less than a third of the time during which mammals have existed.

More important still, this so-called Age of Mammals includes only the last part of mammalian history. When it dawned, the evolutionary progress and fundamental differentiation of the Mammalia were already about two-thirds complete. The student of recent mammals deals with relatively static, completed products. The student of Tertiary history, so far as the record is available, can trace the origin of modern species, genera, and families, but the primary differentiation of the class and even the origin of the orders elude him. At the beginning of the Tertiary, in the Paleocene and Eocene epochs, the orders of mammals were already distinct, although they were still so similar in some respects that their divergence may not have been long antecedent, geologically speaking.

The fundamental evolution of the Mammalia, so important to any student of mammalogy, was entirely pre-Tertiary. It belongs to mammalian pre-history, to the vast span of the Mesozoic Era. This era is famous as the "Age of Reptiles," in

deference to its rulers, but in a very real sense it was also an age of mammals, for the higher class was in existence throughout the greater part of the era and, although quite obscure, was then undergoing a part of its evolution so essential that the more spectacular Tertiary developments almost seem a mere elaboration of what had already been plotted.

The study of origins is always peculiarly difficult. The later dominant and large mammals have left abundant, even if not complete, records. The struggle for their inherited advantages, on the contrary, and the acquisition of the characters and potentialities which led to their supremacy were undergone by small beasts crushed beneath the weight of reptilian hordes. The grand destiny of these precursors could never have been imagined. They were of little apparent importance in the economy of the age. They led obscure lives and in contemporary records they left little trace of their existence. These were the Mesozoic mammals.

Even after the significance and general sequence of fossil animals was beginning to be appreciated, the existence of Mesozoic mammals was at first unsuspected or denied. It was about 1812 when a fossil jaw, imbedded in a rock of Jurassic age, was found by "an ancient stonemason" near Oxford in England and, through W. J. Broderip, then a student, brought to the attention of Professor Buckland. This was a mammal jaw and it came from a deposit formed at a time when, according to the geologic theory of that day, no mammals existed. By 1824 the future dean's convictions had conquered his

cautious orthodoxy and he announced the discovery. By 1840, after a storm of discussion, it was universally accepted.

Many other specimens of Mesozoic mammals have since been found, but they still remain by reason of their rarity and significance among the most precious of fossils, and by reason of their imperfections among the most difficult to study and to interpret. The collections are relatively small, certainly not one thousandth as large as those which represent the much shorter Tertiary history of mammals. It would be ridiculous to expect the materials in hand to answer all of the vital questions naturally referred to them, but it seems equally clear that any student of life should know something more of the existence and of the character of these materials than has been generally available. Details regarding the subject have been given by the present writer, chiefly in two memoirs (Simpson, 1928A, 1929) which describe most of the known specimens and give complete bibliographies. The aim of the present paper is to give a brief résumé, free of cumbersome details of interest only to the specialist, which may aid mammalogists and biologists in the general understanding of the subject.

About fifteen museums contain some significant specimens of Mesozoic mammals, but the collections of paramount importance are four in number: that in the British Museum (Natural History), chiefly described by Sir Richard Owen (1871) and by Henry Fairfield Osborn (1888); the collection in the Peabody Museum of Yale University, made for and described by Professor Marsh (1887, 1889, 1892); a smaller collection with the same history in the United States National Museum; and the material in the American Museum of Natural History, in small part from the collection of Professor Cope, but chiefly from Museum expeditions, originally de-

scribed by Osborn, Matthew, Gregory, and the present writer. The specimens in these collections are chiefly isolated jaws and teeth, but a few more complete skulls make important exceptions and there are also some isolated skeletal parts.

CLASSIFICATION

Any phyletic line must meet one of three fates with the passage of time: it may die out without issue, or it may be modified until its members differ considerably from their ancestry, or it may survive with relatively little change. Historically, our accepted system of mammalian classification was based in the first instance on the successful lines only, on those which survive today. As fossil mammals were discovered, it was generally (and very properly) attempted to fit them into the groups exemplified by recent forms. Now, however, it is common knowledge that if we go back to the beginning of the Tertiary, not long after the ordinal differentiation of the Eutheria, we find along with the orders of the recent system others which will not enter into a classification based on living animals only. Some of the lines of this original eutherian divergence died out without issue and others have been almost unrecognizably changed.

Going still farther back to the very remote time of the original differentiation of the Class Mammalia, the same difficulty is found. As more and more data accumulate, the earlier almost universal tendency to force all the Triassic and Jurassic mammals into orders, superorders, and subclasses based only on the few lines that survived some six or eight score millions of years to the Recent, or even some three score into the early Tertiary seems to be doomed to eventual failure. There are some Jurassic mammals which clearly belong in or near these favored groups, notably the Pantotheria (see below).

Close analysis of what is known of other groups, such as the Triconodonta or Multituberculata, shows that they will not readily enter into even the larger divisions of the recent system and that the evidence usually cited for so placing them is erroneous or equivocal. The eventual major division of the Mammalia must abandon exclusive devotion to those which happened to survive and must take cognizance of the earliest mammals.

It is patent that data for radical revision are still inadequate, but more is known of Mesozoic mammals than is usually supposed. The coordination with later mammals on a basis recognizing their distinction, isolation, and importance is worthy of an attempt which, however tentative and impermanent, should be interesting and perhaps useful. Such an attempt is here presented in outline. The phylogenetic views on which it rests are briefly discussed below.

- CLASS MAMMALIA
 - SUBCLASS PROTOTHERIA
 - Order Monotremata
 - SUBCLASS ALLOTHERIA
 - Order Multituberculata
 - SUBCLASS THERIA
 - INFRACCLASS PANTOTHERIA
 - Order Symmetrodonta
 - Order Pantotheria (*sensu stricto*)
 - INFRACCLASS METATHERIA
 - Order Marsupialia
 - INFRACCLASS EUTHERIA
 - Orders, various
- Incerta sedis*: Order Triconodonta

For convenience, a family classification of the more typically Mesozoic orders is also given:

- ORDER MULTITUBERCVLATA
 - SUBORDER TRITYLODONTOIDEA
 - Family Tritylodontidæ
 - SUBORDER PLAGIAULACOIDEA
 - Family Plagiaulacidæ
 - Family Ptilodontidæ
 - Family Tæniolabididæ

- ?Multituberculata *incerta sedis*: Family Microcleptidæ
- ORDER TRICONODONTA
 - Family Triconodontidæ
- ORDER SYMMETRODONTA
 - Family Spalacotheriidæ
 - Family Amphidontidæ
- ORDER PANTOTHERIA
 - Family Amphitheriidæ
 - Family Paurodontidæ
 - Family Dryolestidæ
 - Family Docodontidæ

DISTRIBUTION

The localities where remains of Mesozoic mammals have been found are relatively few and widely scattered. They represent only a small proportion of the actual geographic range of these groups, and they also represent a rather limited part of Mesozoic time. Furthermore, the majority of these occurrences have yielded few and very imperfect specimens. Fortunately, however, they are so situated in space as to give some conception of geographic distribution and in time as to give important vistas of mammalian life at several strategic periods in the early history of the class.

The accompanying map (Fig. 1), Figs. 2 and 3 and table 1 sum up the essential facts of known geographic and geologic distribution.

TRIASSIC MAMMALS

The oldest known mammals come from the late Triassic and from transitional Triassic-Jurassic rocks in England, Germany, and southern Africa (In addition to the memoirs cited above, see: Simpson, G. G., 1928B; Huene, E. von, 1933). They belong to two groups, the Tritylodontidæ and the Microcleptidæ. The former is known chiefly from the front part of a single skull from South Africa, type of *Tritylodon longavus* Owen, now preserved in the British Museum. It is relatively large for a Mesozoic mammal,

TABLE 1
Distribution of Mammals in the Mesozoic

	TRIASSIC			JURASSIC			CRETACEOUS		TERTIARY
	Lower	Middle	Upper	Lower	Middle	Upper	Lower	Upper	
MULTITUBERCULATA.....									
TRITYLODONTOIDEA.....									
Tritylodontidæ.....									
PLAGIAULACOIDEA.....									
Plagiaulacidæ.....									
Ptilodontidæ.....									
Tæniolabididæ.....									
<i>Inc. sed.</i>									
Microcleptidæ.....									
TRICONODONTA.....									
Triconodontidæ.....									
SYMMETRODONTA.....									
Spalacotheriidæ.....									
Amphidontidæ.....									
PANTOTHERIA.....									
Amphitheriidæ.....									
Paurodontidæ.....									
Dryolestidæ.....									
Docodontidæ.....									
MARSUPIALIA.....									
Didelphiidæ.....									
INSECTIVORA.....									
Zalambdalestidæ.....									
Deltatheridiidæ.....									?
Leptictidæ.....								?	

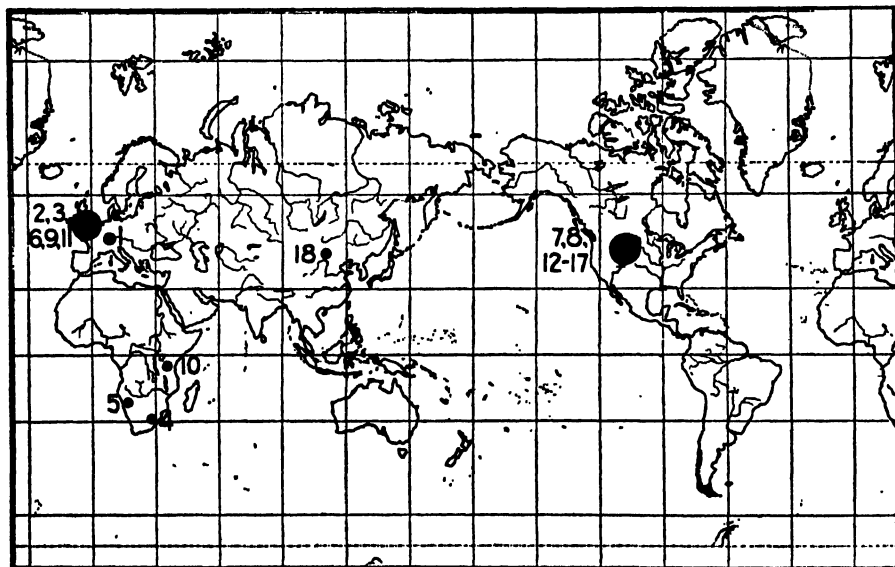


FIG. 1. GEOGRAPHIC DISTRIBUTION OF KNOWN MESOZOIC MAMMALS.
The numerals correspond with those on Fig. 2.

the skull probably over fifteen centimeters in length when complete. The sagittal crest is high and stout, the zygomatic arches arise opposite the anterior cheek teeth, and the snout is blunt, somewhat depressed, and expanded at the end. Septomaxillary bones, seldom recognizable in recent mammals, are present between the nasals, maxillaries, and premaxillaries, but in spite of occasional statements to the contrary no exclusively reptilian osteological characters are shown by the skull

from the whole Mesozoic, yet its affinities have long been in dispute. Its mammalian character, once questioned, seems well established, unless our conception of the class be radically changed. It is generally and with fairly good evidence referred to the Multituberculata, but it is very different from any later multituberculate with a single exception (mentioned below). The most satisfactory view at present seems to be to consider it as in an early side branch (suborder) of the Multituberculata,

PERIOD		NORTH AMERICA	EUROPE	AFRICA	ASIA
CRETACEOUS	UPPER	LANCASHIRE CREEK— Montana-Wyoming, S. Dak. EDMONTON—Alberta BELLY RIVER—Alberta	14, 15, 16, 17 13		DJADOKHTA—Mongolia 18
	LOWER				
JURASSIC	UPPER	MORRISON—Wyo Colorado	WEALDEN—Sussex PURBECK—Dorsetshire	TENDAGURU—Tanganyika	
	MIDDLE		STONESFIELD—Oxfordshire		
	LOWER				
TRIASSIC	UPPER	1 2, 3	1 2, 3 RHÄTO-LIAS—Württemberg RHÄTIC—Somersetshire	4 5 STORMBERG—Basutoland Southwest Africa	
	MIDDLE				
	LOWER				
CORRELATION OF MAMMAL-BEARING FORMATIONS OF THE MESOZOIC ERA					

FIG. 2. GEOLOGICAL DISTRIBUTION OF KNOWN MESOZOIC MAMMALS

The individual occurrences are numbered, 1-18

as preserved. The dentition consists of three incisors, the second very much enlarged and the others reduced, and of seven cheek teeth. The latter cannot certainly be divided into premolars and molars. The typical cheek teeth were almost square and bear three rows of from two to four subcrescentic cusps separated by deep and perfectly straight longitudinal grooves.

This specimen, one of the earliest known mammals, is among the most complete

rather distantly and indeed somewhat doubtfully related to the more typical members of that Order.

Isolated teeth from Württemberg (*Tritylodon fraasi*, *Chaleportherium*, *Oligokyphus*, *Mucrotherium*) seem to be related to *Tritylodon longevus* and to establish the presence of the group in central Europe at about the same time as in South Africa.

The second group of Triassic or earliest Jurassic mammals, that of the Microcleptidae, is known only by isolated teeth

from Somersetshire in England and Württemberg in Germany. These teeth are very small, generally about two milli-

meters in length, and the crowns have an elongate valley surrounded by a cuspidate rim, the cusps unequal in size and less

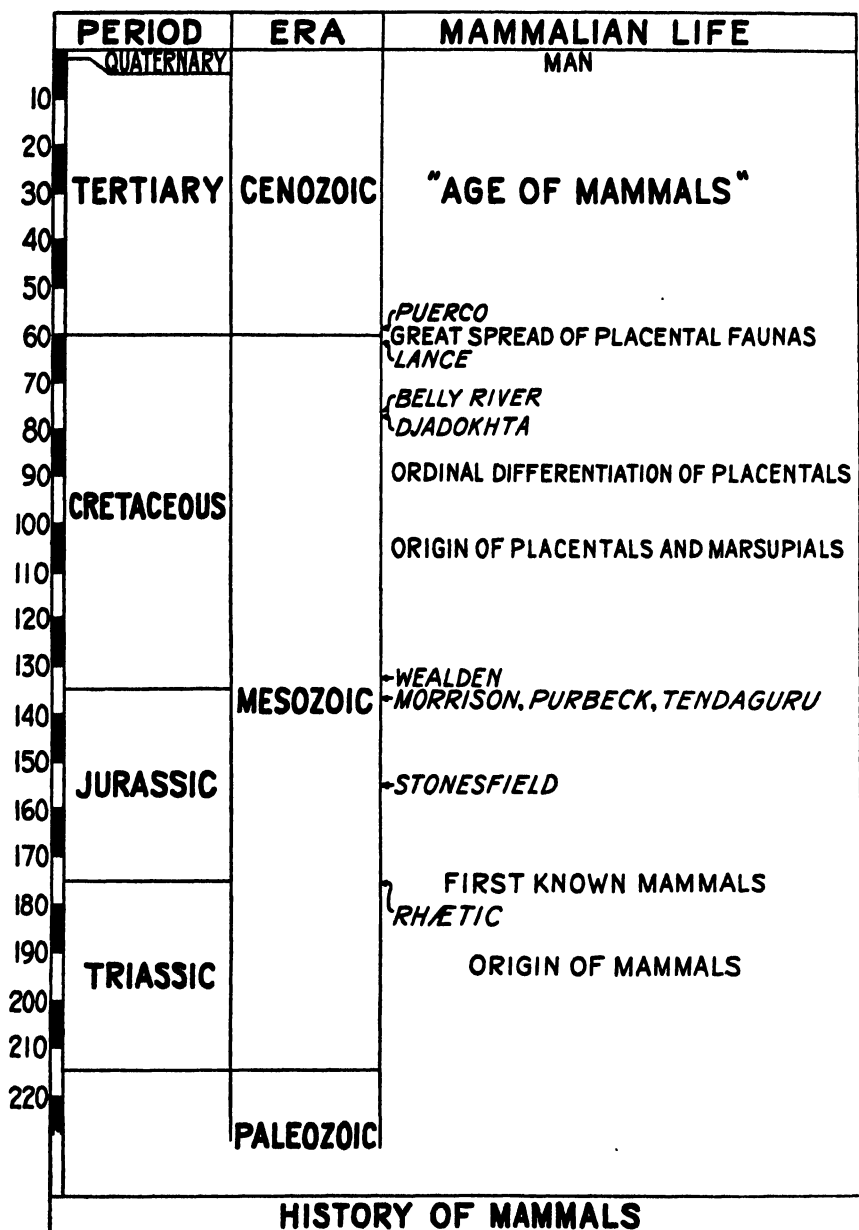


FIG. 3. OUTLINE OF THE MAJOR EVENTS IN MAMMALIAN HISTORY

The scale on the left is in millions of years, based on recent estimates (especially on radioactive disintegration of minerals). In the right hand column the principal known mammal-bearing formations of the Mesozoic (and Puerco, earliest Cenozoic) are given in italic capitals and the principal historical events, in part inferred, in roman capitals.

numerous on one side than on the other. It was at one time believed that these teeth were very like those of upper Jurassic multituberculates, but renewed and more detailed study reveals very important differences and greatly reduces the apparent probability of true relationships. The microcleptids can be admitted to the Multituberculata only in default of better evidence. Their significance for mammalian history is thus wholly questionable, with considerable probability that they are not closely related to any later mammals.

The most recent discoveries of Triassic mammals, made after previous reviews of



FIG. 4. TRITYLODON LONGÆVUS. OUTLINE OF SKULL, RIGHT LATERAL VIEW
Two-thirds natural size

the subject, are those described by Erika von Huene (1933). At Gaisbrunnen, another Württemberg locality similar to those of the other Rhaetic discoveries of that region, were found *Mucrotherium*, a new genus allied to *Chalepotherium* (or perhaps synonymous, as the isolated type teeth are not homologous), *Uniserium*, a wholly doubtful form apparently with a single row of cusps, a possible representative of the genus *Microcleptes*, and two unidentifiable teeth suggestive of the plagiaulacids and of the pantotheres but too doubtful to be taken as really indicating the presence of those groups. These very interesting discoveries suggest that the mammalian fauna was more varied

than previously indicated, but they hardly advance exact knowledge of its nature.

These Triassic assemblages are distinctly disappointing from a phylogenetic point of view. They cast little or no light on the origin of later mammals. It is paradoxical, but in the present state of knowledge true, that more can be learned of Triassic mammals from a study of the more advanced theromorph reptiles than from the true mammals of the period.

A third group of supposed Triassic mammals includes *Dromatherium* and *Microconodon* in the United States, *Karoomys* and *Tribolodon* in South Africa. It now seems fairly certain that none of these is really mammalian. They are advanced mammal-like reptiles, important for mammalian origins, but not of immediate concern here.

JURASSIC MAMMALS

Jurassic mammals are much better known and those known are much more important than those of the Triassic. Three significant faunas have been discovered: in the Middle Jurassic, that of the Stonesfield slate near Oxford in England; in the uppermost Jurassic approximately contemporaneous faunas from the Purbeckian of the Isle of Purbeck, Dorsetshire, and from the Morrison Formation at Como Bluff, Wyoming. Specimens of less importance have been found in the Morrison of Garden Park, Colorado, and in the Tendaguru of German East Africa (Tanganyika Territory)—the latter only a lower jaw without teeth, but the only Jurassic record outside England or the United States.

These Jurassic mammals are readily divisible into four distinctive groups, now defined as Orders: Multituberculata, Triconodonta, Symmetrodonta, and Pantotheria. The last three are confined to the Jurassic, but Multituberculates sur-

vived through the Cretaceous and Paleocene into the Eocene.

Jurassic Multituberculates

Multituberculates are the best known of all the Mesozoic groups and are no less characteristic of that era because they survived it and did not become extinct until the Eocene. In the Jurassic two sorts of multituberculates occur, one

In the Upper Jurassic English Purbeckian and American Morrison, on the contrary, multituberculates are fairly numerous. Several genera occur, of which *Plagiaulax* and *Ctenacodon* are the most noteworthy. They are all rather similar and form the family Plagiaulacidae. They are not closely related to *Tritylodon* or to *Stereognathus* but are the forerunners of a separate suborder, the Plagiaulacoidea,

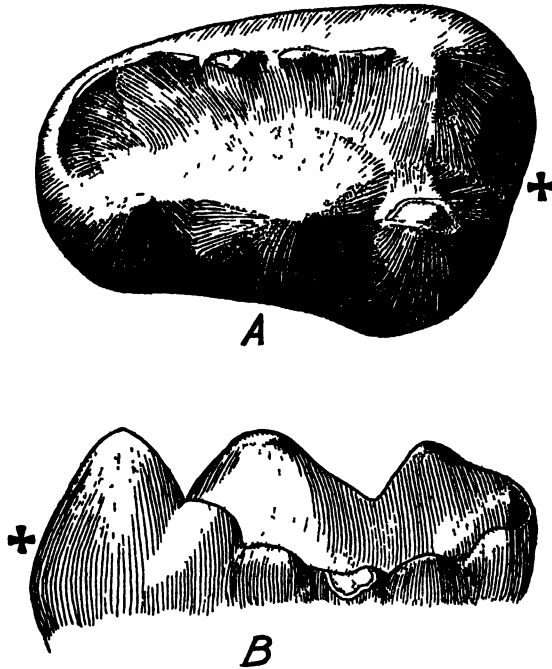


FIG 5 MICROCLEPTES MOOREI, A RHÄTIC MICROCLEPTID

Isolated tooth. A, Crown view. B, Side view. The cross marks the same end in the two views. Thirty times natural size.

group in the Middle Jurassic and one in the Upper.

In the Stonesfield fauna of the Middle Jurassic there is only one multituberculate, *Stereognathus*, and it is known by only two specimens. The interpretation of its fragmentary remains is doubtful, but they probably represent the upper jaws of an animal allied to the Triassic *Tritylodon*. The teeth are quadrate, with three longitudinal rows of two cusps each.

which includes all Upper Jurassic and later multituberculates.

These animals are like none other known, living or extinct. The skull, highly distinctive in later forms, is almost unknown in the Jurassic, but the jaws and teeth define and exemplify the primitive and distinctive characters of the suborder. The lower jaw is short, stout, inclined downward in life. The coronoid process is small, and there is no true angular

process, the pterygoid muscles both being inserted along a continuous, non-angulate crest on the inner side of the jaw. The single pair of lower incisors is enlarged, while in the upper jaw there are three pairs, the second being enlarged as in *Tristylodon*. The lower premolars are three or four in number in the plagiaulacids and together they form a compressed shearing

paucituberculate multituberculates, for their molars have only from five to eight cusps, not numerous as compared with most other mammals. The arrangement, however, is more essential than the number and this is characteristic: on each molar they occur in two longitudinal rows of from two to four cusps each, separated by a longitudinal groove. An apparently

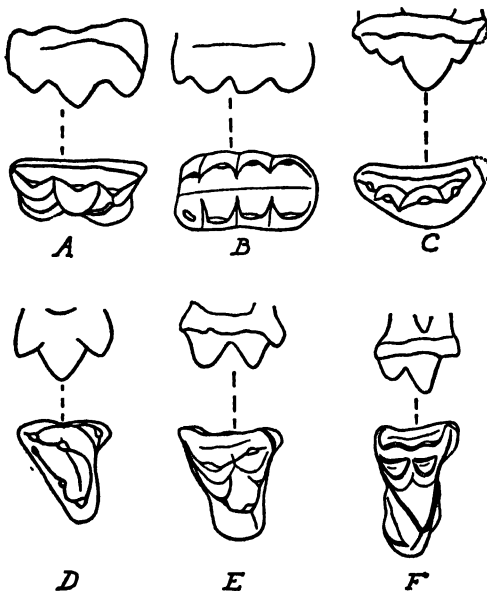


FIG. 6. TYPICAL UPPER MOLARS OF EACH OF THE SIX ORDERS OF MAMMALS KNOWN FROM THE MESOZOIC

External and crown views of each. A, Triconodonts (*Prisacodon*, Upper Jurassic). B, Multituberculata (*Cimacodon*, Upper Jurassic). C, Symmetrodonta (*Eurylambda*, Upper Jurassic). D, Pantotheria (*Melanodon*, Upper Jurassic). E, Marsupialia (*Pedionomys*, Upper Cretaceous). F, Insectivora (*Gypsonictops*, Upper Cretaceous). Not to scale.

wall with serrated apex and crested sides. There are five upper premolars, the first three triangular, with three conical cusps, not opposing the lower premolars, the last two larger, with more numerous cusps in two rows, forming an upper shearing edge opposed to the lower premolars.

Were it not for the contradiction in terms, the plagiaulacids might be called

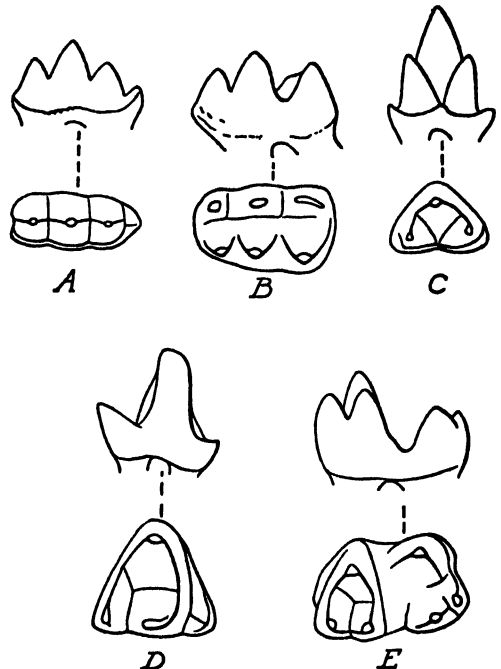


FIG. 7. TYPICAL LOWER MOLARS OF FIVE OF THE SIX ORDERS OF MAMMALS KNOWN FROM THE MESOZOIC

Internal and crown views of each. A, Triconodonts (*Prisacodon*, Upper Jurassic). B, Multituberculata (*Cimacodon*, Upper Jurassic). C, Symmetrodonta (*Timodon*, Upper Jurassic). D, Pantotheria (*Dryolestes*, Upper Jurassic). E, Marsupialia (*Delphodon*, Upper Cretaceous). Not to scale.

abnormal character, but one with a definite bearing on the origin of later multituberculate molar types, is seen in the fact that the two upper molars are so placed that the outer row of the second is in line with the inner row of the first.

This type of dentition has three localized functions: piercing and holding by the enlarged incisors, cutting by the pre-

molars, and grinding by the molars. It is an interesting and very peculiar arrangement, the use of which, so far as may be inferred, seems to be for a diet of seeds, small fruits, and other vegetable food, (see Simpson, 1926), although the opposite view of carnivorous habits has also been maintained.

the Order belongs. Multituberculates have been considered as especially related to the placentals, to the marsupials, and to the monotremes, as well as to all and none of these. Where such definite relationship has been supposed to occur, no two students have agreed as to its degree or kind. However, the great recent advance

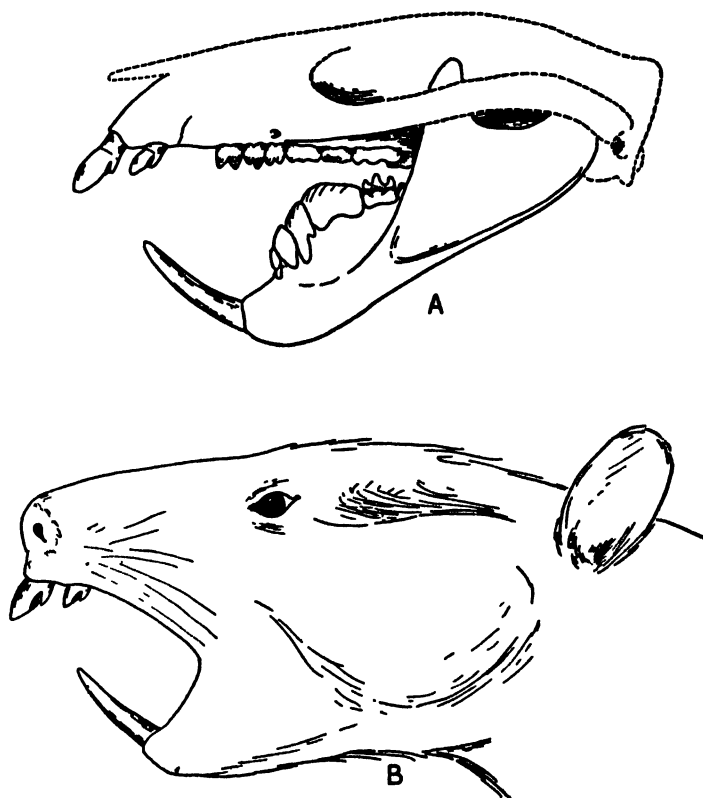


FIG. 8. CTENACODON, AN UPPER JURASSIC PLAGIAULACID

A, Reconstructed skull and jaws; the parts in continuous lines are a composite of all known specimens and those in broken lines are conjectural or based on related genera. B, Tentative life restoration; based on the accompanying skull reconstruction and on a careful restoration of the jaw musculature. Three times natural size.

The multituberculates are known in most detail from post-Jurassic specimens, but conclusions based on all the materials may be expressed here as equally applicable to the Jurassic forms. At least a dozen views as to their affinities have been advanced, and these differ not merely in detail but even as to the subclass to which

in knowledge of this group seems to reduce the theories now reasonably tenable to two: the multituberculates are either related to the ancestry of the monotremes, or they are a sidebranch of the Mammalia distinct since the very beginning of the Class.

The arguments are complicated by the

relatively large number of facts now known about various multituberculates. Resemblances to the monotremes are seen in certain (rather superficial) cranial characters such as the reduction of the lachrymals and jugals, in the absence of a mandibular angular process, the position of the external auditory meatus, etc. On the other hand an almost insuperable complex of peculiar characters opposes this view. The dentition (contrary to some earlier opinions) is radically unlike that of *Ornithorhynchus* or of any other later mammals. The skull structure so far as known does not appear to present any deep-seated, non-adaptive monotreme characteristics. The skeleton is very different and at least in the Cretaceous and early Tertiary forms cannot possibly have given rise to that of the living monotremes even indirectly or structurally.

At present there is certainly no clear basis for referring the multituberculates to any of the modern mammalian subclasses or infraclasses. In fact the evidence seems sufficiently complete to establish a positive probability that they are not related in any intimate way to these recent groups but are a distinct and totally extinct early offshoot of the Class as a whole. If this is true, its only convenient taxonomic expression is the rather radical step, briefly suggested by Granger, endorsed by Matthew, and strongly supported by the present writer, of placing them in a separate subclass, the *Allotheria*.

Although its members never reached great size and although they are so little known to recent zoologists, the multituberculates formed one of the greatest mammalian orders. Their recorded duration was as long as for any other mammalian order and during this time they spread over most of the world, attained considerable variety in size and character, and occupied a commanding position in early mammalian assemblages.

Why such a long-lived and outstanding group did become extinct in the Lower Eocene is perhaps all too fertile a ground for speculation, but there is an interesting possibility. Functionally, although not anatomically, the multituberculates closely resemble the rodents. It is probable that their ecologic position was similar and that, like the rodents, they thrived greatly as a result of possessing a habitus not closely paralleled by their contemporaries. True rodents underwent an expansion at the beginning of the Lower Eocene, then appearing suddenly and for the first time in American and European strata. Multituberculates underwent an almost immediate reduction, so far as the known record is trustworthy, but survived as stragglers along with the rodents until by the end of the Lower Eocene they became totally extinct. The introduction of the more progressive rodents and the waning and extinction of the very archaic but hitherto successful multituberculates may well have been cause and effect.

Triconodonts

Triconodonts occur in three known deposits: Stonesfield, Purbeckian, and Morrison. Seven genera are known, but these are all rather similar and have been placed in two groups, subfamilies, in a single family. The lower jaw agrees with that of the multituberculates in the absence of an angular process, but differs in the relatively long and horizontal tooth-bearing ramus and in the large and strong coronoid process. The incisors, three or four in number, are small, subequal, and simple, while the canines, absent in multituberculates, are large and laniary. The premolars are grasping or cutting teeth with a central cusp and one or two accessory cusps. The molars are rather different in detail in the upper and lower jaws and also in the various genera, but the

common plan is of three main cusps in a straight longitudinal series, with cingula and cingular cusps variously developed.

Amphilestes, from the Stonesfield Middle Jurassic, appears to be the most primitive known member of the group. In it the dental formula is $I_4C_1P_4M_3$. The premolars are symmetrical with large central

worthy are reductions in number of cheek teeth to P_4M_4 , P_2M_4 , or P_4M_3 , asymmetrical development of the premolars, and the subequal development of the three main molar cusps, culminating in *Triconodon* itself.

The cheek dentition as a whole forms a serrated shearing edge. Upper and lower

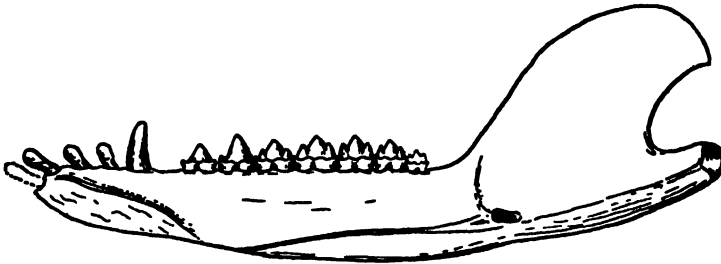


FIG. 9. PHASCOLOTHERIUM BUCKLANDI, A MIDDLE JURASSIC TRICONODONT
Internal view of right lower jaw. Two and one-half times natural size

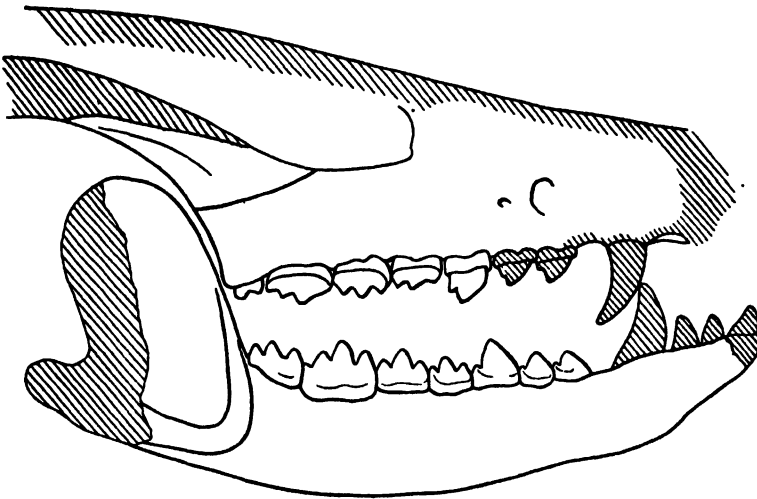


FIG. 10. PRIACODON, AN UPPER JURASSIC TRICONODONT

Composite reconstruction of part of skull and jaws, right lateral view. The cross-hatched parts are not known in this genus. Three times natural size.

and small anterior and posterior accessory cusps. On the molars the central cusp is much larger than the anterior and posterior cusps. *Phascolotherium*, from the same deposit, and two surviving genera in the Morrison are similar to *Amphilestes* except in characters which are probably due to evolutionary advance. Most note-

series were very strongly pressed together in occlusion by an unusual mechanical adaptation, too complex for full discussion here, and the teeth as found are usually much worn. All that is known of osteology and dentition in this group points strongly to predaceous carnivorous habits.

Unlike the case of the Multituberculata, opinion regarding the affinities of the triconodonts has been almost unanimous and has related them most closely to the marsupials. Unfortunately none of the arguments advanced in favor of this view is valid. The dental formula and tooth replacement (partly known in one form) are not marsupial, the mandibular angle is not inflected—in fact, does not exist. No distinctively marsupial or metatherian characters are known in triconodonts. So far as the much less extensive evidence goes, the triconodonts occupy as isolated a position among Mammalia as do the multituberculates. The supposed relationships between triconodonts and pantotheres also rested on faulty evidence.

Knowledge of triconodonts is largely confined to the teeth, and the probable history of these seems fairly clear. The teeth of the Middle Jurassic triconodonts are similar to those of various Triassic mammal-like reptiles, so similar that, in conjunction with other evidence bearing on mammalian origins, a theory of direct derivation is quite tenable. The Upper Jurassic triconodonts are more advanced and seem to reveal a definite line of development which does not, as sometimes supposed, tend to lead to any contemporaneous or subsequent known type of dentition. Too little is known to place the triconodonts as other than *incerta sedis* at present, but it seems probable that they represent another and relatively short-lived independent offshoot from the basal theromorph-mammal stock.

Symmetrodonts

Least known of Jurassic orders is the Symmetrodonta, occurring only in the late Jurassic Purbeckian and Morrison. The jaw is not unlike that of the triconodonts in adaptive type. Incisors, canines, and premolars are also rather

similar, being of the primitive type seen in the earlier stages of most mammalian orders, but the molars are fundamentally different. The lower molars consist essentially of three cusps disposed in a triangle and nearly symmetrical with respect to a vertical transverse plane. These teeth are complicated by the presence of cingula and cingular cusps, but there is no true posterior heel. The single external cusp is higher than the two internal cusps. The upper molars are also triangular, with a high internal cusp, lesser cusps on its antero- and posteroexternal slopes, and a broad, feebly cuspidate outer shelf. The triangular upper and lower teeth interlock in occlusion and their sharp, oblique anterior and posterior edges shear past each other.

Such are the typical characters of the symmetrodonts as seen in the genera *Spalacotherium* and *Tinodon*. Recently, however, another genus, named *Amphidon*, has been discovered in the American Morrison collections which is sharply different from these although probably related to them. The lower molars are triangular, as before, but are almost unique in having but one functional cusp, while the internal cusps of the other symmetrodonts are apparently represented by mere crenulations on the shearing edges of this cusp.

Many students have placed the symmetrodonts in the Order Triconodonta, an opinion supported by the presence of three cusps on the lower molars in each group and by the somewhat similar development of the posterior part of the lower jaw, but opposed by more numerous and apparently more important characters. The question has been influenced by the supposition that a gradation between the triconodonts and the symmetrodonts occurred. This now is found to have been due to the imperfect preservation and preparation of

the available materials. The transition does not really exist, and the symmetrodonts and triconodonts are found to be very distinct. The lower molars of symmetrodonts are triangular, not antero-posterior, occlusion is that of alternating trigons, and the upper molars are so very different as to offer almost no points of comparison.

Similarly, the supposed transition between symmetrodonts and pantotheres does not exist and these groups also are quite distinct. There is, however, some basic resemblance which may prove to be an indication of distant affinity seen especially in the possession in common of triangular, interlocking molars with the

be the most important for phylogenetic investigation.

Amphitherium is the only genus known from the Middle Jurassic. It is the earliest pantothere and, incidentally, was the first Mesozoic mammal to be named and made known. Its importance is very great as it is the oldest known mammal with a tuberculosectorial dentition—that is, forecasting the type almost universal in primitive members of the higher mammalian groups of the Tertiary and Recent. Only the lower jaw is known, but this is worthy of more detailed description than that of any other single genus.

The jaw itself is long and slender, with a stout coronoid process, condyle elevated

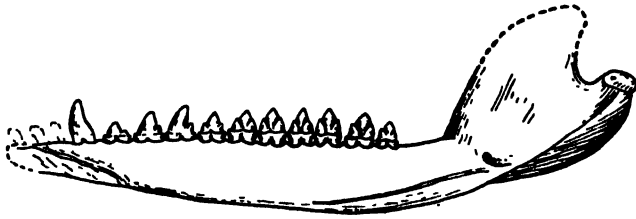


FIG. 11. SPALACOTHERIUM TRICUSPIDENS, AN UPPER JURASSIC SYMMETRODONT
Internal view of right lower jaw. Two and one-half times natural size.

main apices internal above and external below. Beyond that the resemblance does not go, and the retention of the symmetrodonts as a distinct order possibly superordinally related to the pantotheres seems the most acceptable provisional hypothesis. It is highly improbable that it represents an ancestral pantotherian structural stage, and it is not as closely related to any known later mammals as are the pantotheres.

Pantotheres

Among all Jurassic mammals the pantotheres (trituberculates of Osborn in a systematic, but not a morphologic sense) are most abundant in numbers and most varied in character. They also appear to

above the molar level, and a distinct, uninflected angular process which projects downward and backward. The tooth series, including even the incisors, is almost straight. The dental formula is $I_4C_1P_4M_7$ —a larger number than in any heterodont Tertiary or Recent mammal. The incisors are well spaced, small, subequal, slightly procumbent, and spatulate. The canine is relatively large and has two stout but closely appressed roots. The four premolars increase progressively in size and each consists of a laterally compressed main cusp followed by a small and low accessory cusp or heel. The seven molars are all of about the same size and structure, each consisting of a trigonid and a talonid as in primitive later mam-

mals. The trigonid is composed of three cusps which do not surround a closed basin. The highest cusp (protoconid) is external, the internal and anterointernal cusps (metaconid, paraconid) subequal and connected to the external cusp, but not to each other, by sharp crests. The posterior heel, or talonid, is triangular, much smaller than the trigonid, and is not basined but slopes outward and downward. It has but one cusp, posterior in position. Each of the eleven cheek teeth is implanted by two equal roots.

So far as lower teeth are concerned, the Upper Jurassic pantotheres fall into three groups, each of which might be derived

Purbeckian and in the Morrison. Among the more important genera are *Amblotherium*, common to the two formations, the American *Dryolestes*, and the British *Phascolestes*.

The third family, Docodontidæ, is very peculiar and aberrant. Its affinities are clearly pantotherian, but the molars are much more complicated than in any other pantotheres. The lower molars have basined heels with two cusps and the trigonids have four more or less distinct cusps, while the pattern is further complicated by various cuspules, furrows, etc. *Docodon* is fairly common in the Morrison, and a single specimen referable to this family

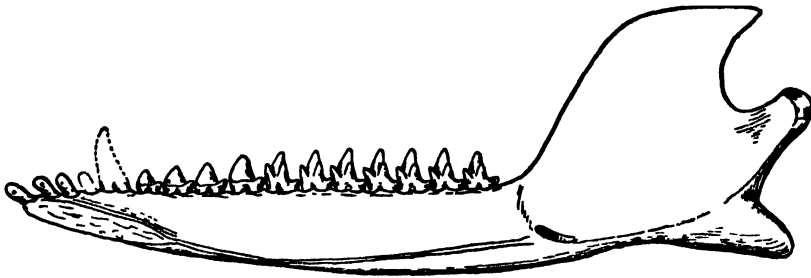


FIG. 12. AMPHISTERIUM PREVOSTII, A MIDDLE JURASSIC PANTOTHERE
Internal view of right lower jaw. Four times natural size

from *Amphistherium* or a similar genus. In one group, the family Paurodontidæ, the cheek teeth are generally similar to those of *Amphistherium* but much less numerous. The family includes two American genera besides the type *Paurodon*, and probably the English *Peramus* should also be placed here.

In the second group, family Dryolestidæ, the cheek teeth are as numerous as in *Amphistherium*, eleven or twelve in number, but the molars are more crowded, shorter anteroposteriorly, heel shorter and cusp more internal, the posterior root much smaller than the anterior and confined to the inner side of the tooth. Members of this family are numerous both in the

and named *Peraiocynodon* has recently been recognized in the Purbeckian.

The upper molars of pantotheres have been found in association with the lower teeth in three specimens only, all from the Purbeckian. Until recently the upper dentitions were very poorly known, but now a series of previously undescribed Morrison specimens in the Marsh Collection has been rediscovered and studied. These are not associated with lower teeth, but they are surely pantotherian and they reveal a varied series of quite peculiar dental structures. Future work on dental evolution cannot fail to take them into account. Aside from the upper molars of *Docodon*, they show certain fundamental

characters, however various the details. All are triangular in outline, and most are transversely elongate. All have a prominent internal cusp and a basined crown external to this. The anterior and posterior rims of this basin may or may not bear small cuspules, and a median ridge in the basin is sometimes present. The external margin bears three cusps in all

The upper teeth of *Docodon*, like the lowers, have a distinct resemblance to those of other pantotheres but are differently specialized. There is a large external cusp preceded by a cingular cusp and followed by an accessory cusp and joined by a transverse crest to the somewhat smaller internal cusp, posterior to which, in turn, there is a small accessory cuspule,

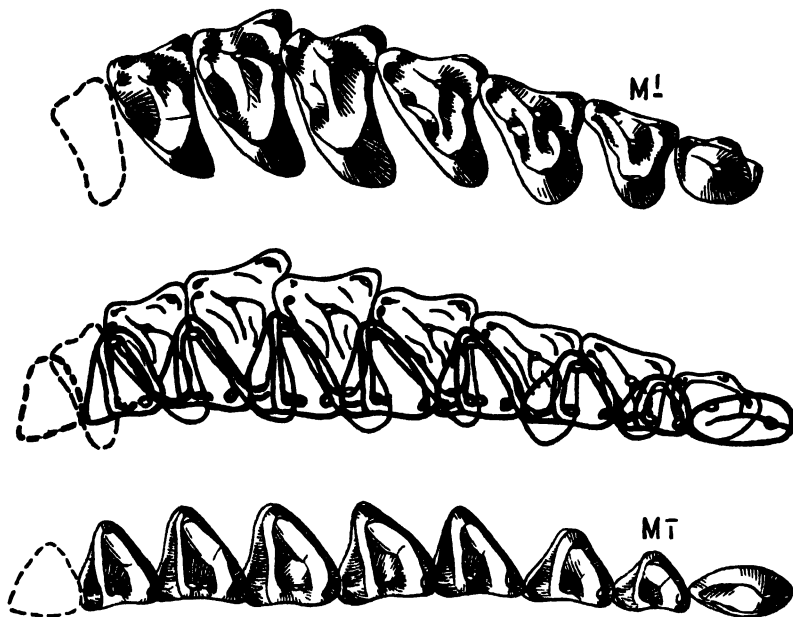


FIG. 13. CHEEK TEETH AND OCCLUSION IN UPPER JURASSIC PANTOTHERES

Top, *Melanodon owens*, right upper molars and last premolar, crown view. Bottom, *Laolestes emineus*, left lower molars and last premolar. Middle, occlusion diagram, lower teeth in heavier outline. Upper and lower teeth were not found in association and since there are several genera with about the same occlusal characters and size it is not certain that they belong together, but, for the same reasons, it is clear that this represents diagrammatically the typical occlusal relations of dryolestid pantothere teeth. About eight times natural size.

cases, and occasionally faint indications of another. Of the three, the anterior and posterior are always small, while the median one may be but little larger or may be very prominent, as large as the internal cusp. Such teeth are not like any others known and are not what might have been anticipated, but they are invaluable in giving actual Jurassic representatives of the primitive tuberculosectorial line, however aberrant some of them may eventually prove to be.

the whole complicated by definite grooves and ridges on the enamel.

Multituberculates, triconodonts, and symmetrodonts are all unlike other mammals and even detailed analysis fails to connect them definitely with any later groups, but only confirms the opinion that they are very early, extinct side branches of the Mammalia. With the pantotheres the case is different, for they obviously have numerous essential, although confusing, resemblances to later

mammals. Again opinion has been divided. They have been considered as related to the monotremes (Winge), to the marsupials (Cuvier, Owen), to the placentals (Marsh, 1887; Osborn), and to both marsupials and placentals (Marsh, 1880; Gregory). Winge's theory of monotreme relationships is purely theoretical and the positive evidence is strongly opposed to it. It is not now tenable. The problem may most simply be stated as

does it permit a ready choice between marsupial and placental affinities.

Evidence of special marsupial affinities can be found only in the common presence of more than three incisors and of more than three molars, but the dental formula does not exactly agree with the marsupials in any case and the premolars are usually four in number. Valid evidence of special placental affinities is seen only in the usual presence of four premolars and in the non-

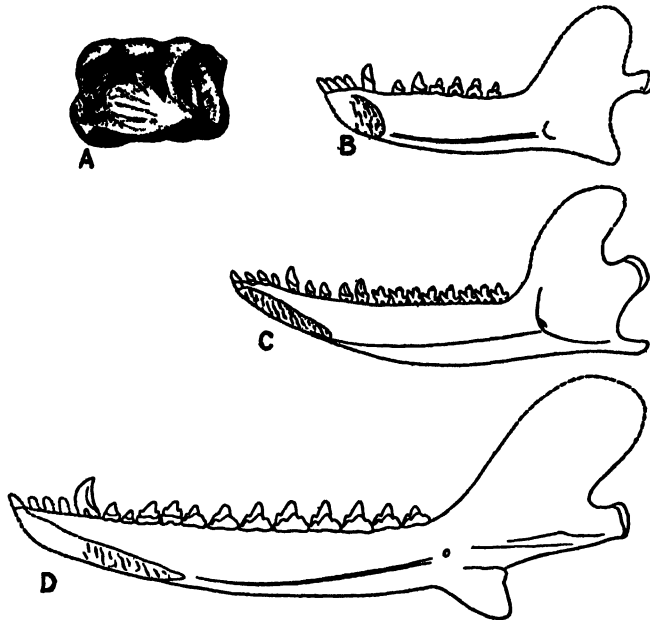


FIG. 14. SOME AMERICAN UPPER JURASSIC PANTOTHERES

A, *Decodon*, crown view of right lower molar. B, *Pseudodon*, internal view of right lower jaw. C, *Laolestes*, internal view of right lower jaw. D, *Decodon*, internal view of right lower jaw. A, ten times natural size; others twice natural size.

follows: the dentitions of the pantotheres, while atypical in their simplicity and in some aberrant features, are clearly tuberculosectorial in general pattern as are the dentitions of most Cretaceous and Paleocene marsupials and placentals; the jaw structure and other known osteological features are also similar; the resemblance is sufficiently close to impel belief in true relationship; but it does not point clearly to any one group of later mammals, nor

inflected angular process, but again the complete dental formula is not really that of any placental. The strongest item is the non-inflected angle, but this is not invariable in placentals, occurs in one known marsupial, and is the only type known among mammal-like reptiles. It is improbable that the angular processes of marsupials and of placentals, so similar in structure and identical in function, are of independent origin. One type or the

other is probably ancestral for both groups. Rather than proving placental relationships for the Pantotheria, this single character seems to support the theory, founded on other evidence, that a non-inflected angle was a character of the remote therian ancestry as a whole.

Aside from this one character, and perhaps including it, the pantotheres as a group have in the known parts all the characters which must have occurred in the common ancestry of marsupials and placentals and none exclusive to either. Incomplete as the evidence is, it supports the important theory that the pantotheres do represent the common ancestry of the Metatheria and Eutheria, not in any one known genus or even family, but as structural representatives, individually more or less aberrant, of a stage of mammalian evolution before the definitive separation of these two great groups.

Amphitherium has no characters certainly excluding it from direct ancestry of later forms, but of course the chance of this isolated find's actually being such an ancestor is extremely small. The paurodonts show reduction in tooth number, even beyond the point of the most primitive placentals and marsupials, but retention of more or less *Amphitherium*-like pattern. The dryolestids retained a high number of teeth, perhaps even increasing the number slightly, but the pattern became modified chiefly by anteroposterior compression of the cheek teeth, analogous to the development of the zalambdodont insectivores in later times but quite independent and on a much more primitive basis. The docodonts were an early, one might almost say premature, attempt at molar complication which did not at all follow the analogous advances later made on the basis of a more progressive fundamental structure.

It may be interesting and even salutary

to abstract the general dental characters of the primitive Theria on the hypothesis that these are structurally represented by the Pantotheria. That the results actually represent ancestral conditions is not quite certain but I believe them to be very probable and in any event they are based on facts more significant than the many highly speculative views which consider only later and relatively highly organized mammals.

1. The dentition fully heterodont, with incisors, canines, premolars and molars sharply differentiated.

2. The primitive dental formula probably $I_4^2 C_1^1 P_4^4 M_7^{2-3?}$.

3. The tooth series closed, but not crowded, and disposed in a nearly straight line.

4. Incisors styliform to spatulate, each with one cusp and one root, more or less procumbent.

5. Canines moderately large, with one cusp and an ill defined heel, often but not invariably two-rooted.

6. Premolars two-rooted, laterally compressed, one main cusp and a posterior heel.

7. Lower molars typically tuberculo-sectorial, with simple three-cusped trigonid, but with talonid relatively small, unbasined, with only one cusp; implanted by two roots.

8. Upper molars trigonal but not strictly tritubercular, somewhat elongate transversely, with a main inner cusp and a main outer cusp opposite it, the latter followed by a posteroexternal accessory cusp and preceded by a simple anteroexternal heel.

CRETACEOUS MAMMALS

The mammals of the Lower Cretaceous are almost entirely unknown. The exceptions are a few isolated teeth from the Wealden formation of England. The only one of these which is determinable,

Loxaulax valdensis, is a close relative of *Plagiaulax* or *Ctenacodon*, a slightly more advanced plagiaulacid multituberculate.

Upper Cretaceous mammals are much better known. The first collections made were from the late Cretaceous Lance formation of Wyoming. These collections are numerically the largest, but consist mostly of isolated teeth with a very few imperfect jaws. The earlier Belly River formation of Alberta has yielded few specimens, but these include three well preserved jaws. A few other relatively

Cretaceous Multituberculates

Multituberculates are relatively abundant in the Lance and contemporary formations of North America and the group is also represented by a partial skull and jaws, with associated skeletal parts, from Mongolia. All of these seem to be related to the Jurassic plagiaulacids, but they are much more advanced and have some characters which may indicate that the relationship is not directly ancestral. All are tentatively placed in the family Ptilodontidæ, based on the Paleocene

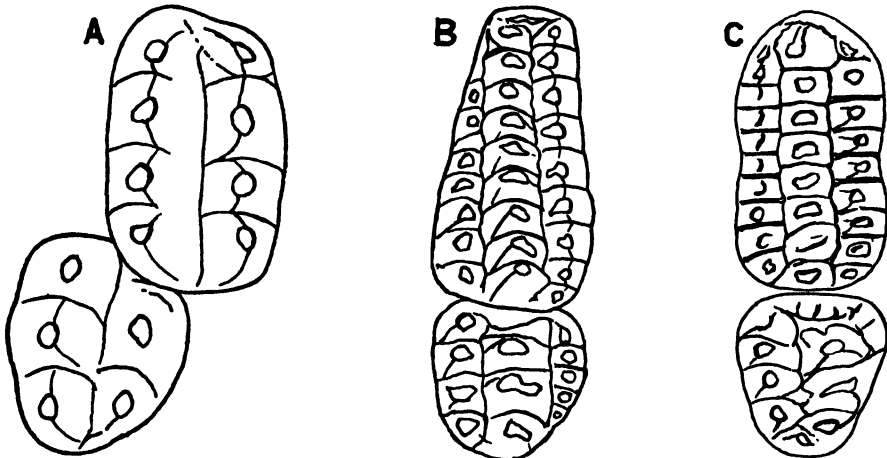


FIG. 15. UPPER MOLARS OF MULTITUBERCULATES

Crown views of the two left upper molars, anterior end up. A, *Ctenacodon*, Upper Jurassic. B, *Cimolomys*, Upper Cretaceous. C, *Taeniolabis*, Paleocene. Not to scale.

unimportant discoveries have been made in North America. In South America, the lower jaw of an opossum, described by F. Ameghino under the name *Proteodidelphys*, was formerly accepted as of Cretaceous age, but it now seems almost certain that it is from the Tertiary. The recent expeditions of the American Museum of Natural History in Mongolia discovered remains of eleven individuals of Upper Cretaceous mammals in the Djadochta formation. These include skulls, jaws, and even skeletal parts and are incomparably the best known specimens of Mesozoic mammals.

Ptilodus. The following characters of the American forms, especially *Cimolomys* and *Meniscoessus* give a conception of the degree and nature of the advance over the plagiaulacids:

1. Lower premolars are reduced to two, one of which is vestigial and may be lost in later (Paleocene and Eocene) genera. In the plagiaulacids they are three or four in number. The last premolar in the Cretaceous forms is relatively larger and has a greater number of serrations.
2. The first lower molar is larger than the second and has a large number of

cusps. In the plagiaulacids the molars are subequal and both have few cusps.

3. There were probably only three or four upper premolars, as in Paleocene genera, although this is uncertain. There are five in plagiaulacids.

4. Only the last upper premolar is shearing in function. The last two are shearing teeth in plagiaulacids.

5. The upper molars are unequal in size, like the lowers, and they have three rows of cusps. In the plagiaulacids they are subequal and have but two rows.

closely related to the Jurassic plagiaulacids although much more highly specialized.

Cretaceous Marsupials

None of the Jurassic mammals were referred to the Marsupialia because none were found to have definitely marsupialian, as against merely primitive, characters. In the American Upper Cretaceous not only are indubitable marsupials present, but they constitute the greater part of the fauna and are much varied in size and character. Various specimens have

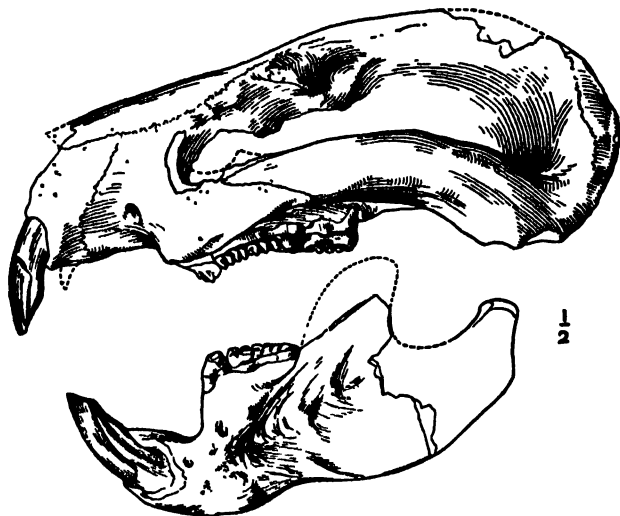


FIG. 16 *TARNIOLABIS TAÖENSIS*, LOWER PALEOCENE MULTITUBERCULATE
Left side view of skull and jaw. One-half natural size. (After Granger and Simpson.)

6. The molar cusps are more or less crescentic and complicated by grooves and ridges. Those of the plagiaulacids are nearly conical and quite simple.

Djadochtherium, the Mongolian genus, shares the reduction in the premolars and has various peculiar specializations, but the first lower molars appear to be almost as simple as in the Jurassic forms.

The important general facts are that multituberculates continue to form a large and important part of the mammalian fauna, that they exhibit considerable variety, but that all appear to be rather

shown that they have not only the primitive marsupial dental formula, but also the inflected angular process, palatal vacuities, and other characteristics of the order. In most of them the teeth are strikingly like those of the recent opossums, so that they may even be placed in the same family, at least until more important differences are demonstrated.

These most opossum-like of the Cretaceous marsupials differ from the recent animals chiefly in quite minor characters, such as the equal size of the main outer cusps (paracone and metacone) of the

upper molars, the more uniform development and higher number (five) of the cingulum cusps or styles external to these, or the fact that the third premolar is the largest, rather than the second. One of the most remarkable facts of paleontology is the slight evolution apparently undergone by this group during the Tertiary. The recent opossum is almost a living Cretaceous mammal.

These Cretaceous opossums were, however, much more varied than are recent opossums and although many are very like the latter some are decidedly different. Besides the central and less specialized type (e.g. *Pediomys*), there are others with the molar cusps remarkably high, sharp, and piercing (*Nyssodon*), and still others with broad heavy molars associated with great blunt premolars and with short deep jaws (e.g. *Tblaodon*).

Marsupials as such probably arose during Lower Cretaceous time. The oldest actually known is *Eodelphis* from the Upper Cretaceous of Alberta, and in the Jurassic are forms perhaps structurally ancestral but certainly not true marsupials. At the end of the Cretaceous in North America, at least, they were represented by varied but closely related forms all on about the same evolutionary level as the living opossums. It is probable that the more specialized Tertiary forms of South America and recent forms of Australia were eventual products of the differentiation the beginning of which is suggested by this Cretaceous fauna. In North America itself all but the most conservative line disappeared with the great influx of placentals at the beginning of the Tertiary, but in South America the marsupials were partly and in Australia almost wholly free of placental competition, for some unknown reason.

The absence of marsupials in the Mongolian Cretaceous fauna is unexpected,

but certainly does not warrant the very improbable conclusion that they were then absent in Asia. This absence of specimens may be entirely accidental, as only eleven mammalian specimens are yet known from the Cretaceous of that continent, or it may be due to the fact that the known material is from a facies unfavorable to the contemporaneous marsupials.

Cretaceous Insectivores

Although the bulk of the so-called tri-tubercular or tuberculosectorial teeth from the American Cretaceous clearly belong to marsupials, certain of them do represent early placentals. These are rare and isolated and little can be said of them other than that they indicate the probable presence of two or three genera of insectivores and that the best defined (*Gypsonictops*) is apparently related to the extinct lower Tertiary family Leptictidæ. Indeed the very existence of Cretaceous placentals among the known specimens was questioned, but the recent discoveries in Mongolia have placed this beyond doubt.

Here were found partial or complete skulls and lower jaws of four genera and five species. These are just as truly placental mammals as the bulk of the American Cretaceous mammals are marsupials. The dental formula and other diagnostic features of the placentals were already typically established at the time of the deposition of the Djadochta formation, approximately contemporaneous with the earliest known marsupials in North America.

The Mongolian Cretaceous insectivores fall into two groups, Deltatheridiidæ and Zalambdalestidæ, typified by the genera *Deltatheridium* and *Zalambdalestes*, which are not widely different but suggest the beginning of divergent lines.

The first family, Deltatheridiidae, is the less specialized. The premolars and molars have a broad outer shelf. The lower molars have

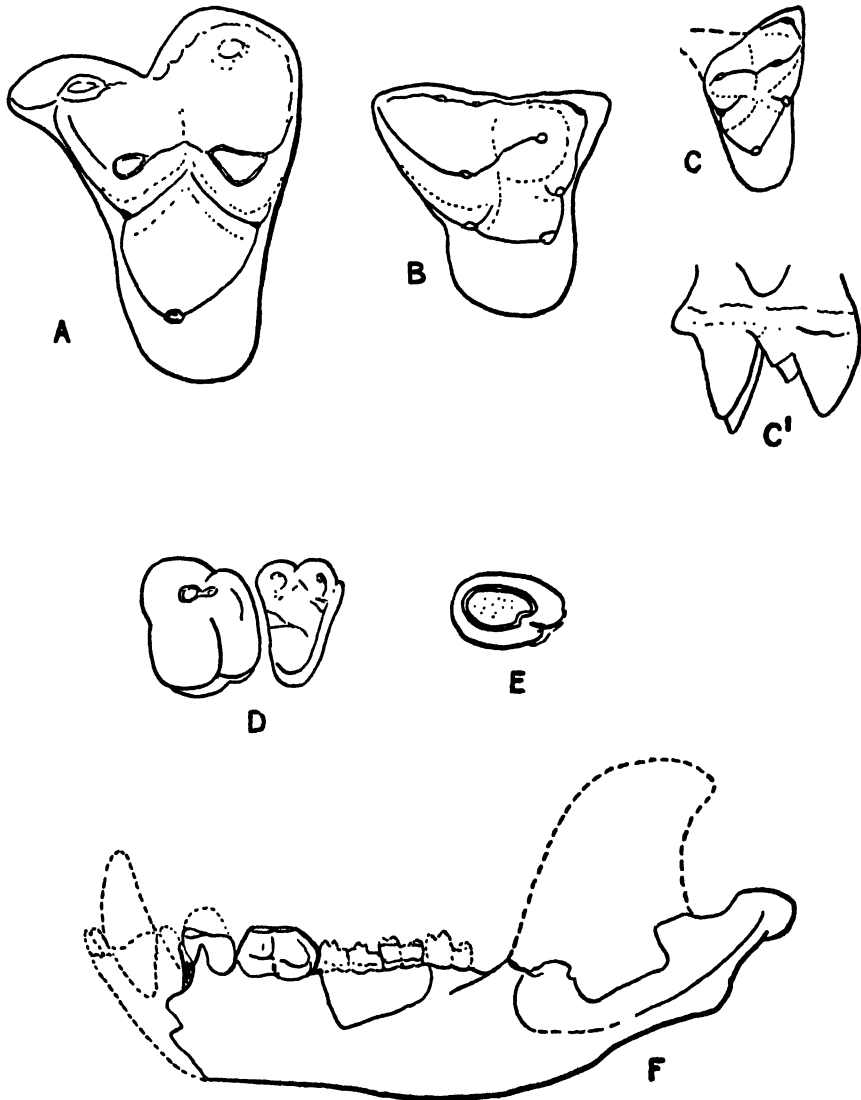


FIG. 17. UPPER CRETACEOUS MARSUPIALS

A, *Didelphodon*, crown view of left upper molar. B, *Pedimys*, crown view of right upper molar. C, *Nyssodon*, crown view of left upper molar. C', Same, posterior view. D, E, F, *Thlaodon*. D, Crown view of left last upper molar and first molar. E, Crown view of left last lower premolar. F, External view of left lower jaw. A-C, six times natural size. D-F, not to exact scale (D about two, E about one and one-half, and F about one). (D-F redrawn after Matthew.)

molars are sharply distinct; the upper molars have an internal cusp (protocone), two median cusps (paracone and meta-

rather long narrow heels, but otherwise are simply tuberculosectorial with three trigonid and three talonid cusps as in most

Paleocene mammals. The canines are rather large and laniary. The snout is fairly short, the braincase somewhat expanded, not tubular, and the skull generally of primitive insectivore-creodont type. Such specialization as is present seems to foreshadow the creodonts and the family suggests Matthew's hypothetical group of Cretaceous insectivores ancestral to the Carnivora. From a broader point of view, it seems but little advanced from a condition which could be structurally ancestral to many or perhaps even to all placental mammals.

may be enlarged. The snout is long and slender, somewhat depressed anteriorly, and the braincase is rather long and tubular, the skull generally of insectivore type. The closest resemblance of the zalambdalestids is with the later Leptictidæ, but they are not directly ancestral to the latter.

Briefly recapitulating the positive facts regarding Cretaceous placentals, they are known to have been in existence some time before the close of the period, the known genera are all very primitive and do not show distinct differentiation into

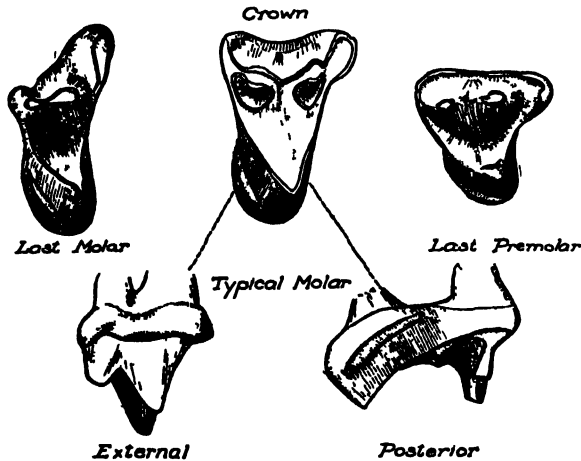


FIG. 18 *GYPSONICTOPS HYPOCONUS*, AMERICAN UPPER CRETACEOUS INSECTIVORE
Various isolated upper teeth, as labeled Eight times natural size

The other family, Zalambdalestidæ, is on a similar very primitive plane but is slightly more advanced and has more definite indications of specializations such as characterize the later Insectivora, aside from their merely unprogressive characters. The posterior premolars are partly molariform; the upper molars are strongly transverse, with partly connate, nearly external paracone and metacone. The lower molars are of primitive tuberculo-sectorial type, but with the trigonids somewhat compressed anteroposteriorly. The incisors are procumbent and one pair

more than one order, but they do show incipient divergence even in the limited materials at hand suggestive of two or more later types of mammals.

On these facts and on what is known of earlier and later mammals certain theories may be based for future more definite proof or disproof: that while ordinal differentiation of the placentals was already under way in Djadochta time it was not long antecedent, that the known forms do give a conception of the structural character of placentals at that time, the other orders not being greatly different, and that pla-

centals as such probably arose, like marsupials and from a common stock with them, in the earlier Cretaceous.

THE HISTORY OF MAMMALS

The known remains of Mesozoic mammals give clear answers to some questions

are important in the negative but salutary sense of checking unreasonable speculation and of indicating those pages of mammalian history which are still blank for us. It is necessary to keep these lacunæ as well in mind as the positive facts, for it has too often happened that they have been ficti-

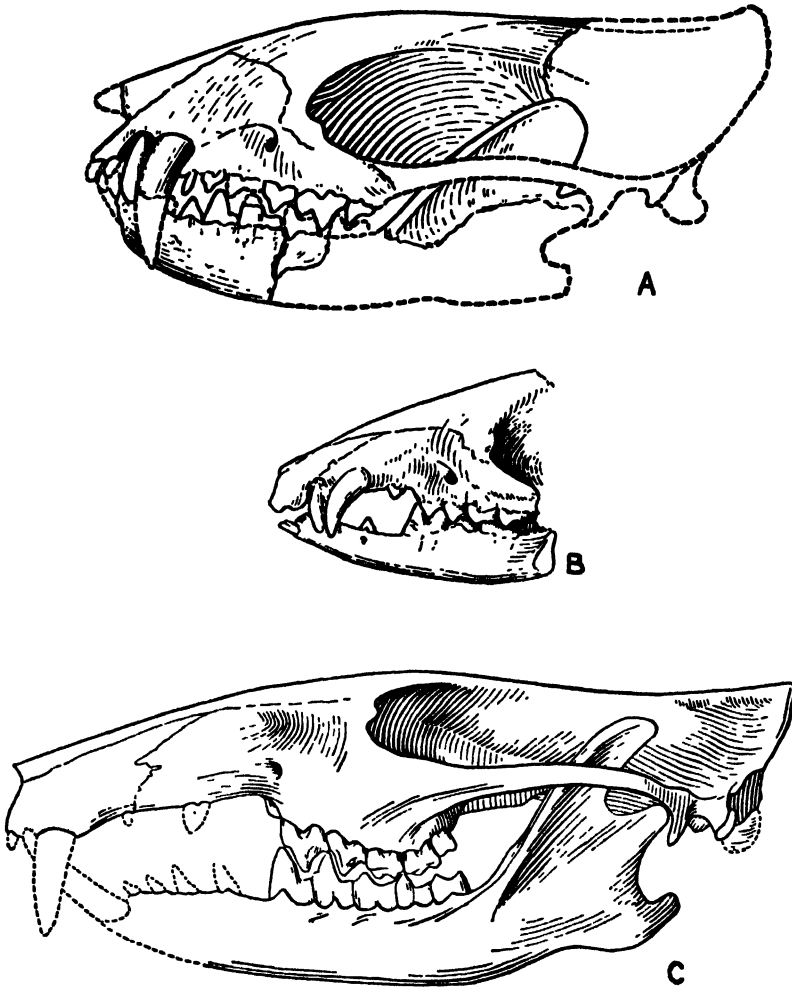


FIG. 19. MONGOLIAN UPPER CRETACEOUS INSECTIVORES

Left side views of skulls and jaws. A, *Deltatheridium pretristuberculare*. B, *Hyotheridium dobsoni*. C, *Zalambdalestes lebei*. All twice natural size. (A and B after Gregory and Simpson.)

regarding the long pre-Tertiary history of the class. Even when they fall far short of certainty or well founded theory, the data here sketched in brief outline

thoroughly filled by speculation and that this speculation has passed from hand to hand until it approaches the fixity of dogma.

Among the points on which the known

remains of Mesozoic mammals cast no light is the geographic place of origin of mammals. Origins are inevitably obscure and, belabor them as we will, paleontological data inevitably involve a large element of chance, the chance of preservation and the chance of discovery. Without questioning its interest, one must certainly question the value of almost all of the now large literature dealing with geographic origins. Once a group has become well established, its subsequent migrations may often be traced in elaborate detail, but the place of actual origin is not surely known for any major group of animals. For mammals as a whole, Africa has been repeatedly advanced as the probable birthplace. This is pure speculation. There are no facts positively opposing the assignment of this rôle to any of the early Mesozoic land masses, and the few facts suggesting Africa are all very inconclusive and more reasonably interpreted as due to chance than as really valid in this sense.

The time of origin of any major taxonomic division can never be exactly established if, as seems highly probable, evolution is essentially continuous, for there can never be an exact point where the ancestry ceases and the descendant group begins. Yet the facts now known permit a very reasonable theory as to the approximate time of origin of the Mammalia. In the general literature, there is a very strong tendency to suppose that a given group arose in the period preceding that in which its oldest known fossils occur: the oldest mammals are Triassic, therefore the mammals are usually said probably to have arisen in the Permian. This, even though it should eventually prove to be correct, is now an example of the uncritical perpetuation of an ill considered opinion. It takes no account of the widely variant lengths of the geological

periods in the more or less arbitrary scale in use, or of the exact date of the first known mammals, or of their real nature, or of much pertinent but collateral evidence. When these considerations are studied, it becomes clear that the only theory tenable on present evidence is that mammals as such arose in the Triassic and that, if, as is quite probable, the origin was not completely monophyletic, the more important and successful lines probably originated rather late in the Triassic and possibly even in the early Jurassic. In the Permian there are no known mammals and no reptiles that are very mammal-like. During the Triassic some reptiles became progressively more and more mammal-like and those closest of all to the higher class occur only in the Upper Triassic, or even possibly in the Lower Jurassic (known chiefly in the Stormberg of South Africa). The oldest known mammals occur in the very top of the Triassic and the base of the Jurassic, contemporaneously with the most mammal-like reptiles. It seems improbable that the origin of the class was much antecedent. And these oldest known mammals are, so far as now appears, outside the ancestry of later mammals, an aberrant basal offshoot. The oldest really archotypic mammal occurs well up in the Middle Jurassic. It is entirely possible that the ancestor of this form at the end of the Triassic was still a reptile by definition, but it is somewhat more probable that the ancestry ceased to be nominally reptilian during the Upper Triassic.

The remains of the earliest mammals do not cast much light on their own ancestry. They do suggest the probability that forms mammalian by definition arose from various different members of some single reptilian group. To this extent the mammals are probably polyphyletic (although this is not taken to in-

validate the essential unity of the Class), but the vast majority of recent mammals, all with the possible exception of the monotremes, are of monophyletic origin in the fullest sense of the words. Approximately what that reptilian group was is known not from the actual mammalian remains but from reptilian fossils. It was almost certainly a group of therapsids and probably very close or actually belonging to the Ictidosauria of Broom.

Whenever and wherever they arose, mammals were widely distributed by the end of the Jurassic. They are known from East Africa, England, and the Rocky Mountain area in North America and although not yet discovered on other continents, had almost surely had the time and opportunity to reach all the major land areas of that period. Judging from the known representatives, mammals had then already undergone a world-wide adaptive radiation. They occupied the diverse stations of life available to land animals of their small size, including carnivorous, herbivorous, insectivorous, and omnivorous types. This mammalian radiation, the first if the dubious Rhæto-Liassic forms are excepted, involved four orders: Multituberculata, Triconodonta, Symmetrodonta, and Pantotheria. Their divergence dated from, or even preceded, the origin of the class and only one group, the less specialized pantotheres, lay near the ancestry of the marsupials and placentals. The two latter groups were apparently not yet in existence as such.

Two of these four Jurassic orders do not reappear in any form in the subsequent record. In some unknown region and during the first half of the Cretaceous, another type of mammalian fauna developed from the other two of the Jurassic orders. This included multituberculates, more progressive than but not profoundly different from those of the

Jurassic, and the potentially much more important marsupials and placentals, each in their most primitive form. The marsupials of this fauna were all opossum-like and the placentals were all insectivore-like. This was certainly the Upper Cretaceous faunal type in North America, and it probably extended over a much greater part of the world, although the distributional evidence is poor and inference can only be tentative. These Upper Cretaceous mammals seem to represent a second great mammalian radiation of distinctive type, involving three orders: Multituberculata, Marsupialia, and Insectivora.

All of these Cretaceous orders survived that period, but the first two were never again dominant faunal elements, at least in the great connected land masses in which the central events of mammalian evolution occurred. In some unknown region and during the later half of the Cretaceous, a third major type of mammalian fauna developed from one of the Cretaceous groups, the primitive placentals. This new fauna was largely composed of the archaic placentals, typical of the Paleocene: condylarths, creodonts, and many less known groups. Their appearance marks the beginning of the Tertiary Period, the true Age of Mammals. They reduced the remnants of the Cretaceous mammalian radiation to relative insignificance in most parts of the earth, and they almost entirely replaced the reptiles ecologically.

Finally, at the beginning of the true Eocene came the fourth and last major mammalian radiation, that of the modernized placentals. During the Lower Eocene the multituberculates finally succumbed, after a recorded history of perhaps 90,000,000 years, and only the opossums and some insectivores retained a definite semblance to the now remote Mesozoic ancestry.

The most impressive point in this sequence of events is the way four successive waves of mammalian faunas of different type seem to have spread over the world, each wave bringing new orders of progressively higher type. Perhaps the greatest mystery in this history is where these faunas came from, and why, and how. The first two radiations are so isolated in present knowledge that it cannot be positively asserted that they did not develop more or less *in situ*, although this does

seem improbable. Regarding the last two, however, so much is known that it is almost inconceivable that they can have developed from preceding faunas where they are found. It seems certain that they originated in some large but isolated area which is unknown paleontologically and that the union of that area with the known parts of the world permitted their sudden spread. Where that cradle of the higher mammals was is a question that still baffles inquiry.

LIST OF LITERATURE

A nearly complete bibliography of the subject is given in Simpson, 1928A and 1929. The following are the several most general and important memoirs, a few shorter papers cited in the text, and those published since 1929:

- BUCKLAND, W. 1824. Notice on *Megalosaurus*. *Trans. Geol. Soc. London*, (2), 1, pp. 390-396. Includes the first mention of the existence of Mesozoic mammals.
- GOODRICH, E. W. 1894. On the fossil Mammalia of the Stonesfield Slate. *Quart. Jour. Micr. Sci.*, 35, pp. 407-431.
- GREGORY, W. K. 1934. A half century of trituberculy. The Cope-Osborn theory of dental evolution. With a revised summary of molar evolution from fish to man. *Proc. Amer. Phil. Soc.*, 73, pp. 169-317. [With references to other recent papers on dental evolution involving Mesozoic mammals.]
- HUENE, E. VON. 1933. Zur Kenntnis des Württembergischen Rätbonebeds mit Zahnfundten neuer Säuger und säugerähnlicher Reptilien. *Jahreshefte Ver. wasserl. Naturkunde Württ.*, 1933, pp. 65-128.
- LYDEKKER, R. 1887. Catalogue of the fossil Mammalia in the British Museum, 5.
- MARBET, O. C. 1887. American Jurassic mammals. *Amer. Jour. Sci.*, (3), 33, pp. 327-348.
- . 1889, 1892. Discovery of Cretaceous Mammalia. *Amer. Jour. Sci.*, (3), 38, pp. 81-92, 177-180; (3), 43, pp. 249-262.
- MATTHEW, W. D. 1916. A marsupial of the Belly River Cretaceous. *Bull. Amer. Mus. Nat. Hist.*, 35, pp. 477-500.
- OSBORN, H. F. 1888. On the structure and classification of the Mesozoic Mammalia. *Jour. Acad. Nat. Sci. Phila.*, 9, pp. 186-264.
- . 1893. Fossil mammals of the Upper Cretaceous. *Bull. Amer. Mus. Nat. Hist.*, 5, pp. 311-330.
- OWEN, R. 1871. Monograph of the fossil Mammalia of the Mesozoic formations. *Paleontogr. Soc.*, 24.
- SIMPSON, G. G. 1926. Mesozoic Mammalia. IV. The multituberculates as living animals. *Amer. Jour. Sci.*, (5), 11, pp. 228-250.
- . 1928A. A catalogue of the Mesozoic Mammalia in the Geological Department of the British Museum. British Museum (Natural History), London.
- . 1928B. Mesozoic Mammalia. X. Some Triassic mammals. *Amer. Jour. Sci.*, (5), 15, pp. 154-167.
- . 1928C. Affinities of the Mongolian Cretaceous insectivores. *Amer. Mus. Novitates*, No. 330.
- . 1929. American Mesozoic Mammalia. *Mam. Peabody Mus. Yale Univ.*, 3, Pt. I.
- . 1930. A new specimen of *Eodelphis cutleri* from the Belly River Formation of Alberta. *Nat. Mus. Canada, Bull.* No. 63, pp. 29-32, 80-81.
- . 1932. The supposed occurrences of Mesozoic mammals in South America. *Amer. Mus. Novitates*, No. 530.
- . 1933A. The "plagiaulacoid" type of mammalian dentition. A study of convergence. *Journ. Mammalogy*, 14, pp. 97-107.
- . 1933B. Paleobiology of Jurassic mammals. *Palaeobiologica*, 5, pp. 127-158.



THE PREMAXILLA IN THE PRIMATES (*Concluded*)

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3. THE PREMAXILLA IN MAN

BEFORE proceeding with the record of my observations it is necessary to ask an important question, and to answer it. This question is: Knowing something of the manner of obliteration of the facial part of the premaxillary suture in man, and the relatively simple manner of obliteration of the same suture in the sub-human Primates, is it a justifiable procedure to compare the simple *datum* of obliteration of this suture in the said Primates with the same *datum* in man? In other words, since a premaxillary suture, according to the majority of our authorities, is not present or distinguishable upon the facial aspect of the skull in man after the third foetal month, owing to its being overgrown by a profusion of ossificatory material, is it a justifiable procedure to compare this manner of obliteration of the premaxillary suture with the simple interstitial manner of obliteration of the same suture in the sub-human Primates? Surely, it is obvious that such a comparison cannot justifiably be made, for we are here dealing with two characteristically different modes of ossification; in the one ossification taking place by the development of an osseous plate above the suture (where the suture exists), although without obliterating it in its greatest extent (for the suture remains widely open beneath this plate for a considerable period after its appearance in man), in the other the suture being obliterated by means of the interstitial proliferation and deposit of ossificatory material between its borders.

Partial persistence of premaxillary suture in the human foetus

How then, if at all, are these two phenomena to be compared? To this question the following considerations supply the answer. In the first place, it is necessary to inquire whether it is in fact true that the premaxillary suture is not distinguishable upon the facial aspect of the human skull after the third foetal month. Our authorities, on the whole, agree that it is not so distinguishable. The observations here recorded, however, are unequivocally positive upon this point, as a result of which it becomes possible to state that the premaxillary suture is frequently visible upon the facial aspect of the skull in man immediately up to the time of birth and in a fair number of cases up to the fifth post-natal year of age. By this I do not mean, what we already know, that the suture is present endofacially, upon the internal nasal aspect of the maxilla, but that it is in fact present upon the externum or facial aspect of the skull. Nor is it meant to convey that the suture is present in its entirety as is the case in the sub-human Primates, but that it is present upon the facial aspect only *partially*. The fact that the premaxillary suture is present at all upon the facial aspect of the human skull is for us the important point.

In the skull of a negro male foetus aged 9.27 months (No. D.A. V), before the writer at the time of writing, the only part of the premaxilla that has been overgrown by the maxillary plate is that portion of it situated immediately below

the base of the pyriform aperture together with a few intermittent sections immediately lateral to its infero-lateral border;

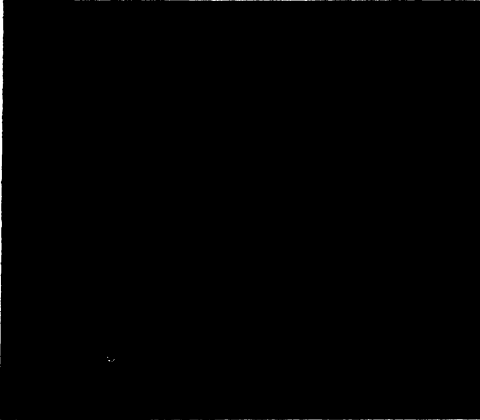


FIG. 4 A. VIEW OF THE RIGHT MAXILLA OF A MALE NEGRO FOETUS AGED 9 27 MONTHS (No. D.A. V) DISPLAYING THE UNOBSERVED SUPERIOR OR APICAL PORTION OF THE PREMAXILLA UPON THE FACIAL ASPECT

The premaxillary suture may be seen superiorly separating the premaxilla from the maxilla.



FIG. 4 B. VIEW OF THE ENDOFACIAL ASPECT OF THE BONE SEEN IN FIG. 4 A

The premaxilla and the suture separating it from the maxilla is here visible in its entirety.

the apex of the naso-maxillary process of the premaxilla remains, however, quite free, and is separated from the maxilla by a widely open suture, (Fig. 4A).

Under the microscope, at a small magnification, this suture has the appearance of a broad chasm,—immediately lateral and inferior to it a cancellous plate of maxillary ossificatory material is present, this plate having quite distinguishably overgrown the inferior portions of the premaxilla. The apical portion of the premaxillary suture, as well as the premaxilla itself, have in this specimen not yet been overgrown by this material, and, indeed, there is now available ample enough evidence to show that the maxillary plate often fails to overgrow the apical portion of the premaxilla, in such cases ossification taking place by the process of simple interstitial growth, as is normally the case in the sub-human Primates. The fact that in this specimen this suture forms the posterior border of the apical premaxilla and that it is continuous with the endofacial premaxillary suture, which runs uninterruptedly open all the way down, and transversely across to the naso-palatine foramen (Fig. 4B) whereat it becomes continuous with the palatine portion of the suture, and terminates laterally at the posterior border of the distal canine wall, proves beyond question that this is none other than the facial part of the premaxillary suture, that is, the apical portion thereof.

Ten additional foetuses have been examined, and in order to check my observations comparatively, these have been divided into negro and white groups of practically equivalent ages, ranging from 4.58 months to 9.31 months of age. Age was determined according to the formula of Scammon and Calkins, 1929 (101).

No. D.A. IV. Male white, aged 4.58 months: The premaxilla has united with the maxilla apically both endo- and ecto-facially, yet without having been covered (apically) by the maxillary plate. Endo-facially the inferior portion of the premaxillary suture is visible in its whole extent towards the naso-palatine foramen.

No. D.A. 134. *Female negro, aged 5.02 months*: Endofacially the premaxillary suture is completely obliterated, only the endopalatine portion being at all visible. Facially the suture is likewise obliterated, but the maxillary plate leaves the apex and the lateral and anterior-inferior margins of the premaxilla, at the pyriform aperture uncovered.

No. D.A. III. *Male white, aged 5.67 months*: Endofacially the premaxillary suture is patent only upon the floor of the nasal fossa. The apical portion of the premaxilla seems to have been overgrown by, or become closely coalesced with, the maxilla in this specimen, so that it becomes difficult to say whether there are any remains of the premaxilla upon the facial aspect of the skull or not. At the base of the pyriform aperture the two plates of bone, the maxilla and the premaxilla, are separated by a deep cleft, so that here, at least, the infero-lateral portion of the premaxilla is facially distinguishable.

No. D.A. 121. *Male negro, aged 6.29 months*: Endofacially the inferior portions of the premaxillary suture are alone visible. Facially the suture is not apparent; the maxillary plate seems to have overgrown the inferior portion of the apex of the premaxilla, but has left the superior portion patent. It has also failed to overgrow the lateral pyriform portions of the premaxilla, and has, on each side, left a crescentic-shaped premaxillary gap.

No. D.A. 100. *Female white, aged 6.80 months*: Endofacially the inferior portions of the premaxillary suture are alone visible. Facially the premaxilla is almost completely overgrown by the maxillary plate, only the lateral portions at the pyriform aperture being still patent.

No. D.A. 140. *Female negro, aged 7.57 months*: Endofacially the apical portion of the premaxillary suture seems to have undergone a recent obliteration, for a hardly distinguishable suture line is still visible in that vicinity. Inferiorly the suture is perfectly patent. Facially the apical premaxilla is not distinguishable from the maxilla, but the associated evidence in this case proves quite conclusively that whilst the apical premaxillary suture has united with the ascending process of the maxilla by a process of simple interstitial growth, the maxillary plate has failed to overgrow this part of the premaxilla and has played no perceptible part in its obliteration, for the limits of the maxillary opercular plate are in this specimen exceptionally distinct. In this case the maxillary plate leaves the apical premaxilla, as well as a good part of the superior medial or lateral pyriform portion, uncovered. The remaining part of the premaxilla inferior and lateral to the infero-lateral angle of the pyriform aperture, is also, though to a lesser extent, left uncovered. The fissure between the

maxillary and premaxillary plates is almost completely ossified, though the premaxilla remains quite clearly visible as an increasingly narrow septum of bone all the way down towards the infero-lateral angle of the pyriform aperture.

No. D.A. II. *Female white, aged 7.62 months*: Endofacially the premaxillary suture is patent all the way down to the naso-palatine foramen; there is, however, no trace of it apically. Facially the premaxilla is not distinguishable, and it would appear that the maxillary plate has overgrown it.

No. D.A. VI. *Male negro, aged 8.55 months*: Endofacially the apical portion of the premaxillary suture is obliterated, inferiorly the suture is perfectly patent. Facially the premaxilla has not completely united with the overlying maxillary plate, and is seen as a narrow lateral border of the pyriform aperture. The apical portion of the premaxilla has completely united with the maxilla, but it seems doubtful whether the maxilla has here actually overgrown the premaxilla, for the bone in this place is extremely thin. Immediately lateral to the infero-lateral angle of the pyriform aperture the maxillary plate and the premaxilla are seen clearly separated from one another, the interval being occupied by a mass of spongy osseous material.

No. D.A. 132. *Male white, aged 8.59 months*: Endofacially as well as ectofacially the premaxillary suture in this specimen is entirely obliterated. The endopalatine portion of the suture is alone visible, whilst the ectopalatine portion is scarcely distinguishable.

No. D.A. V. *Male negro, aged 9.27 months*: This remarkable specimen has already been described. (Figs. 4A & B). Endofacially the premaxillary suture is completely and broadly open, whilst facially, at the apex of the premaxilla a broad suture, or rather fissure, separates the maxilla from the premaxilla, whilst inferiorly and lateral to the pyriform aperture uncovered portions of the premaxilla are also seen.

No. D.A. 118. *Female white, aged 9.31 months*: Endofacially the premaxilla is completely indistinguishable, and this is true, too, facially. The endo-palatine portion of the premaxillary suture is also visible, whilst upon the oral palatine surface it can hardly be distinguished.

One of the most valuable facts brought out by the above observations is that in the negro foetus the premaxilla tends to lose its independence much later than in the white, a fact which can be significantly correlated with the more pronounced facial prognathism of the negro.

This fact and its relationship to the facial form of the negro had already been pointed out by Hamy in 1868 (44).

A summary analysis of the above observations yields the following facts:

Endofacially the premaxillary suture is present inferiorly in four out of five of our negroes, and completely present in the fifth. In the white foetuses this portion of the suture is present in only three out of our six cases.

Facially the apical and pyriform portions of the premaxilla are left exposed and uncovered by the maxillary plate in every one of our negroes.

In the white foetuses this is true in only one out of our six cases. In two other cases the premaxilla is slightly visible either at the base or at the infero-lateral border of the pyriform aperture.

The premaxilla is completely obliterated or obscured both endofacially and facially in two white foetuses.

The premaxilla is *completely* obliterated endofacially only in one white and in one negro foetus.

Facially the premaxilla is completely obliterated or obscured in one white foetus.

It would appear then, that throughout the primates, with few exceptions, the tendency is the same, the greater the degree of *prognathism* the later does the premaxillary suture tend to remain open and unobliterated.

For our immediate purpose, however, the significance of the preceding observations is that they prove, or tend to prove, that in the generality of late foetuses, at least, the premaxilla is not altogether obscured upon the facial aspect of the skull, and that occasionally a sutural separation between the premaxilla and the maxilla may be observed in the vicinity of the apical portion of the premaxilla

upon the facial aspect of the skull. Evidence will shortly be adduced to show that a similar sutural separation between premaxilla and maxilla may occasionally be observed in young human crania up to the conclusion of the fifth year. If this is so then it is clear that the assertion that all traces of the facial premaxilla and its suture disappear in man by the end of the third foetal month is an assertion not in agreement with the facts.

The premaxilla in infants

The following observations with respect to the premaxillary suture were made upon human post-natal crania picked at random.

Male white, newborn: No trace of the premaxilla or its suture endofacially or facially.

Female white, newborn: Slight apical traces of the premaxillary suture present facially and endofacially. Suture patent endofacially inferiorly.

Male negro, newborn: Facially at the supero-lateral margins of the pyriform aperture the premaxilla is visible where it has been left uncovered by the maxillary plate. Endofacially the suture is visible inferiorly to the point where it disappears at the nasopalatine foramen.

Male (?) white, aged 11 months: In this case a very definite suture separates the distinctly visible premaxilla from the maxilla at the apex of the nasomaxillary process of the premaxilla. The suture, as was to be expected, is continuous with the completely patent premaxillary suture endofacially, (Fig. 5).

Female (?), aged 12 months: A slight suture is visible facially, though endofacially the suture appears to be completely obliterated.

Male (?), aged 19 months: A slight suture is visible on the right side only. Endofacially the suture is visible in its entirety on both sides of the skull.

Female white, aged 29 months: A slight suture, about 3.0 mm. in length, is present on both sides facially. Endofacially the suture is present in its entirety.

Female white, aged 5 years: No trace of the premaxilla facially. Endofacially the suture lines are still visible.

Female white, aged 5½ years: Facially very slight traces of a suture are distinguishable apically. Endofacially the suture is seen only inferiorly.

By 29 additional skulls of similar age range the premaxillary suture was not seen upon the facial aspect in a single instance, though endofacially the premaxillary suture was seen either in its whole or partial extent in 23 cases. Thus, up to the end of the fifth year the premaxillary suture was found to be partially present upon the apex of the nasomaxillary process of the premaxilla in 6 out of our 38 crania, or in 15.7 per cent of cases. This figure, to anticipate for a moment, compares interestingly with the figures found for the Anthropomorphae or great apes. In the latter traces of, as well as the completely patent, premaxillary suture were found in 52.2 per cent of cases, in the following distributions: Orang, 68.1 per cent; Chimpanzee, 15.1 per cent; and the Gorilla, 85.7 per cent. Surprisingly enough, from these figures, the conclusion is forced upon one that although the completely patent premaxillary suture is never seen upon the facial aspect of the human skull, whereas in the infant chimpanzee it is occasionally seen, *viz.* in about 3.7 per cent of cases, traces of the suture are more frequently seen in *infant-young* man than either the open or partially open suture is seen in the *infant-young* chimpanzee. The difference is only 0.6 per cent in favor of the chimpanzee, and this would serve to indicate that the rate of interstitial obliteration of the premaxillary suture in the chimpanzee is very slightly faster than the rate of apical interstitial obliteration of the same suture in man. Actually it seems doubtful whether the difference is really a significant one. The fact is, however, as many observers have already noticed, that the premaxillary suture in the chimpanzee begins to undergo obliteration in the late foetal period of development.

My own observations of the maxillary-

premaxillary region made upon human foetuses prove unequivocally and conclusively that, with the exception of the anterior nasal spine and the small areas on either side of it, the premaxilla in man is not normally represented upon the anterior surface of the face below the level of the pyriform aperture. The anterior alveolar walls are *entirely* formed by, what Callender called the incisor processes of, the maxilla. Not only this, in quite late foetal crania from the sixth month



FIG 5. INFANT WHITE SKULL AGED 11 MONTHS SHOWING THE APICAL PORTION OF THE PREMAXILLA AND ITS SUTURE FACIALLY

Upon the endofacial aspect the premaxilla and its suture are clearly visible in their entirety.

to term, the incisor processes may be clearly observed to curve sharply backwards in the median plane, to form together the whole of the alveolar septum which will separate the maxillary central incisors from one another; continuing posteriorly the incisor processes come into contact with the median palatine processes of the premaxilla, at which point they again perform a curve, but this time to pass lateralwards apparently for a distance extending to about one-third of the posterior wall of the central incisor socket, to terminate in a slight tuberosity. Looking within the socket one may observe that

this tuberosity actually constitutes the inferior limit of an incomplete septum which lies anterior to and is separated from the posterior alveolar wall, and which together with a similar septum which originates from the posterior extremity of the lateral incisor septum (both in the fresh condition being completed by a membrane of dense white connective tissue), enclose an appreciable space which is entirely devoted to the germ of the *permanent* incisor tooth. This *transverse septum* is derived from maxilla medially, and from either the premaxilla or the maxillary incisor septum laterally. Anterior to this septum lies the developing crown of the *deciduous* central incisor, which is clearly completely surrounded by maxilla. Posterior to this transverse septum lies the germ of the developing *permanent* central incisor, which but for its anterior wall, the transverse septum, is lodged entirely within the premaxilla. With the eruption of the permanent tooth this septum becomes entirely resorbed and the tooth comes to lie in a socket which is formed anteriorly, medially, and to some extent laterally, by maxilla, and only the lateral two-thirds or three-fourths of the posterior wall of which is formed by maxilla. Anteriorly, except for the anterior nasal spine, there is no trace of the premaxilla whatsoever, it has been completely absorbed by the premaxilla, and were it not for the fact that we possess the descriptions of Nesbitt (16), Leidy (31), and Ranke (69) of foetuses between the tenth and twelfth weeks of development showing the presence of the premaxilla below the pyriform aperture separated from the maxilla by suture lines precisely as in the apes, we might well doubt the existence of the anterior wall of the premaxilla at any stage in the development of man. Actually, after the third month of development the premaxilla below the pyriform

aperture completely disappears in the substance of the maxilla, and in this relation ceases to be present either as an independent lamina of bone or as a part of such. Not only does the maxilla, therefore, form the anterior wall of the incisor sockets, but it also forms the whole of the median alveolar septum which extends between the central incisor sockets and actually forms their medial walls, and in addition, forms a considerable portion, at least, of the transverse septum which separates the developing deciduous from the developing permanent central incisor. It is perfectly clear then, that in man the *anterior wall* of the premaxilla has been completely lost, appearing transitorily only between the tenth and twelfth weeks of development, whenafter it is completely absorbed and its place and function entirely assumed by the maxilla. In addition, it is to be observed that by far the largest portions of the distal septal walls of the incisor sockets are formed by the maxilla and not by the premaxilla. The posterior wall of the permanent central incisor sockets is, with the exception of the medial third which is formed by the maxilla, formed by the premaxilla, the same holds good for the lateral incisor walls, but the medial septal wall of the latter sockets are formed almost entirely by the maxilla, and this is true, too, of the canine distal septal wall. These facts are clearly shown in Figs. 6 and 7.

Thus, it is established that statements to the effect that the premaxilla lodges the incisor teeth in man, are inaccurate, for it has been shown that in man it is only the posterior portion of this bone which assists in the lodgement of these teeth, and that medially the premaxilla has been entirely replaced by the maxilla.

Upon the basis of these findings it at once becomes clear why facial premaxillary suture lines are never observed below

the level of the pyriform aperture in man. The reason is simply that they have already ceased to exist by the end of the third foetal month, having been completely obliterated by proliferations of ossificatory material originating in the maxilla. The premaxilla below this level in this situation has been entirely lost in man, and has been replaced by the maxilla. Thus, man is in this respect unique, in that of all animals possessing incisor teeth he alone is the animal in which the anterior walls, which together with the posterior and lateral walls normally assist in the support of these teeth, are formed by the maxilla and not by the premaxilla as is the case in the latter. In fact, each of the four incisor sockets is, in man, almost entirely formed by the maxilla, whereas in all other animals these sockets are clearly formed entirely by the premaxilla. Thus, it becomes evident that the premaxilla has upon all sides been almost completely replaced by the maxilla, and that only an abbreviated portion of the original bone now exists in the human skull,—upon the palatine aspect orally, upon the anterior part of the floor of the nasal cavity, and upon the walls internally bordering upon the pyriform aperture laterally.

The fact that in certain forms of cleft-palate such, for example, as 'parson's nose,' a condition in which the premaxilla develops completely independently of and anterior to the maxilla, the premaxilla possesses an anterior wall behind which incisor teeth may develop, is by no means a fact incompatible with the description of the normal process of disappearance of this portion of the bone which has been given above. This and other forms of cleft-palate originate during *embryonic* development, long before the appearance of the ossificatory centers for the maxilla and premaxilla. In such abnormal cases

after the appearance of the ossificatory centers each of these bones undergoes an independent development, for the most part completely separated from one another; there can thus be no possibility of the

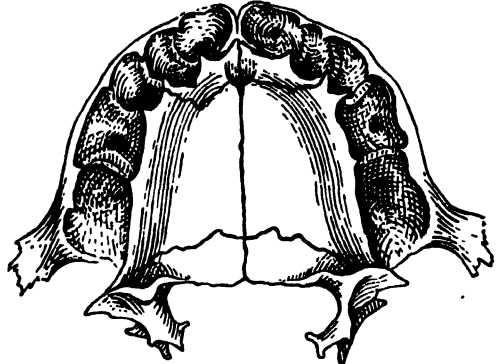


FIG. 6. PALATINE VIEW OF A WHITE FEMALE FOETUS AGED 7.62 MONTHS (No. D.A. II) SHOWING THE PRODUCTION POSTERIORLY OF THE INCISOR PROCESSES OF THE MAXILLA TO MEET THE PREMAXILLA, AND THE BEGINNING DEVELOPMENT OF THE DISTAL WALLS OF THE INCISOR SOCKETS FROM THE MAXILLA

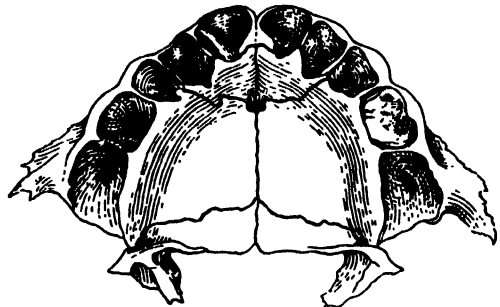


FIG. 7. PALATINE VIEW OF A WHITE FEMALE FOETUS AGED 9.91 MONTHS (No. D.A. III) SHOWING THE MAXILLARY-PREMAXILLARY RELATIONSHIPS

absorption of the anterior wall of the premaxilla.

The obliteration of the premaxillary suture in man unlike that in other Primates

With the help of these observations we are now in something of a position to return an answer to the question as to whether it is a justifiable procedure to

compare the datum of obliteration of the premaxillary suture in man with the same datum in the sub-human Primates.

We have already observed that the manner of obliteration of the premaxilla and its suture is a process which is sensibly different in each group; in the Hominidae the premaxilla, except frequently at its apex, being overgrown by a maxillary plate with which it is not generally completely united until a considerable time after birth, whilst in the sub-human Primates the premaxilla is not overgrown by a maxillary plate at all, but loses its interdependence by a process of simple interstitial union with the adjacent maxilla.

In man the premaxillary suture undoubtedly becomes obliterated superficially beneath the maxillary plate, even though endofacially it is generally found open with free and unclosed borders until a relatively advanced age. Upon the facial aspect a remnant of the suture may be observed upon what appears to be the maxilla but which in fact represents the apical division between the maxilla and the premaxilla.

It should be clear then, that in man we are dealing with a process of obliteration which is radically unlike that which occurs in the sub-human Primates, and that therefore, the superficial comparison of the state of obliteration of the premaxillary suture in man with that of the sub-human Primates is a procedure not morphologically justifiable.

The reduction of the snout

The existence of these differences in the relations and development of the maxillary and premaxillary bones between man and the sub-human Primates leads to the question of aetiology.

A brief consideration of the form of the face in the Primates leaves little room for doubt that the chief factor instrumental in

bringing about this unique change in the maxillo-premaxillary relationship in man has been the progressive and almost total reduction of the snout. The premaxilla, which in the lower mammals and Primates forms an appreciable part of the produced snout, has in man been so completely retracted that it may be said to have been almost totally embraced by the face, the maxillary bones forming a natural *operculum* over it upon every side of the pyriform aperture. Writing recently on the classification of the upper lip in mammals Boyd, 1933 (116) makes some pertinent remarks in this connection; he writes,

The main factor in causing the relative and absolute increase in the maxillary contributions to the face would appear to be the decline in importance of the "oral sense" and the olfactory apparatus. This diminution in the importance of olfaction can be correlated with the decrease in the development of the fronto-nasal process, the maxillary processes becoming progressively more prominent in the formation of the definitive face. Another factor that may have had an influence on the process of substitution of maxillary processes for the fronto-nasal process is the marked increase in the mobility of the lips in the higher Primates.

That the mobility of the lips in the higher Primates has been a factor instrumental in the reduction of the fronto-nasal process seems open to doubt, but that a strong oral and olfactory sense is generally accompanied by a produced snout is a well established fact. The inference seems to be obvious, that with the decrease in the importance of the oral and olfactory senses, there would be, among other things, a concomitant diminution in the visceral-osseous apparatus, an important part of which is formed by the premaxilla. This diminution would express itself in a decrease in the length and size of the snout, the trend of the facial skeleton being towards orthognathism. The more the oral and olfactory senses became

diminished, the smaller the relative size of the premaxilla, and the more reduced the snout would become. In addition to all this there is the important factor represented by the teeth, I mean the canine-maxillary developmental relationships. If, for example, we examine the skull of an adult Catarrhine monkey like *Papio hamadryas* in the anterior dental region, it will be observed that there exists an average diastema of some 8 mm. between the maxillary lateral incisors and the canine teeth; this diastema exists for the reception of the sabre-like mandibular canine, and is almost entirely formed by the premaxilla. In the gibbons an even larger diastema exists to accommodate the large sabre-like mandibular canine. In the orang, in which the canines are relatively reduced, a smaller diastema exists between these teeth. In the chimpanzee in which the canines are still further reduced a still smaller diastema exists. In the gorilla in which the mandibular canine in the male is extremely large and tusk-like, and appreciably larger than in the female, the diastema is relatively large, and below, in the mandible, there is an equivalent diastema. With the reduction of the canines, such as has taken place in man, such a diastema would no longer serve any useful purpose, and would therefore undergo a complete reduction, which in actuality takes the form of a reduction of the postero-lateral region of the premaxilla which in the sub-human Primates provides the structural basis for the diastema. In this manner we may account for the disappearance of the postero-lateral portions of the premaxilla in man.

That this account of the factors which have been responsible for the reduction of the premaxilla in man corresponds, at least, to the facts, the available evidence seems strongly to attest. In the light of

these facts the comparatively great differences in the size, form, and relations of the premaxilla which exist among the Primates, are easily understood.

When then, Wood Jones claims that the "Obliteration of the facial premaxilla is a distinguishing character of man as a species"; and that "it would be used by the systematist as a specific diagnostic feature of *Homo*," the point, I think, may be freely granted, for man alone, of all mammals, is characterized by the peculiar *curtaining* which his premaxilla has undergone in the course of an evolution upon the highest developmental rung of which he now stands. The point that Wood Jones has made, and is here established, is a retro-active one, for the distinctive character which it would serve to emphasize, as distinguished from the remaining Primates, when properly understood, serves in reality to emphasize the close affinity of the hominid to the anthropoid premaxilla, for it is quite clear that the human premaxilla must once have passed through a stage such as that which now characterizes the anthropoids, and indeed it is only possible to understand the peculiar changes which have taken place in the human premaxilla upon the grounds of it being derived from such a type as now characterizes the anthropoids. Upon this matter I shall have something more to say in another section of this study.

4. THE FORM OF THE PREMAXILLA IN THE SUB-HUMAN PRIMATES

In defining the anatomical characters of the Cebidae Professor Wood Jones states with respect to the premaxilla that it "either fails to meet, just meets, or slightly overlaps the lower margin of the nasal in the margin of the narial aperture" (100, p. 200). In the succeeding chapter of the same work (Chap. 28, p. 217) in listing the differences between the

Catarrhinae and the Platyrrhinae he states that in the Catarrhinae, "The premaxilla extends far up the side of the nasal opening and may reach to and articulate with the frontal." In one of his figures (see Fig. 8) he illustrates what he considers to be "the articulations common in (A) the New World, and (B) Old World Monkeys;" in the first (A), the premaxilla articulates narrowly with the base of the nasal bones, and in the second (B), the premaxilla articulates rather less narrowly

the nasal bones, and in the other the premaxillaries are very slightly inserted between the infero-lateral angles of the nasal bones and the maxilla; the latter appears to be the more usual condition and does not seem to be confined to any one particular genus or species.

Cebidae. Among the Cebidae the relations of the premaxilla are variable.

In *Pithecia pithecia* and in *Lagothrix* the premaxillaries turn at right angles across the apex of the pyriform aperture to rein-

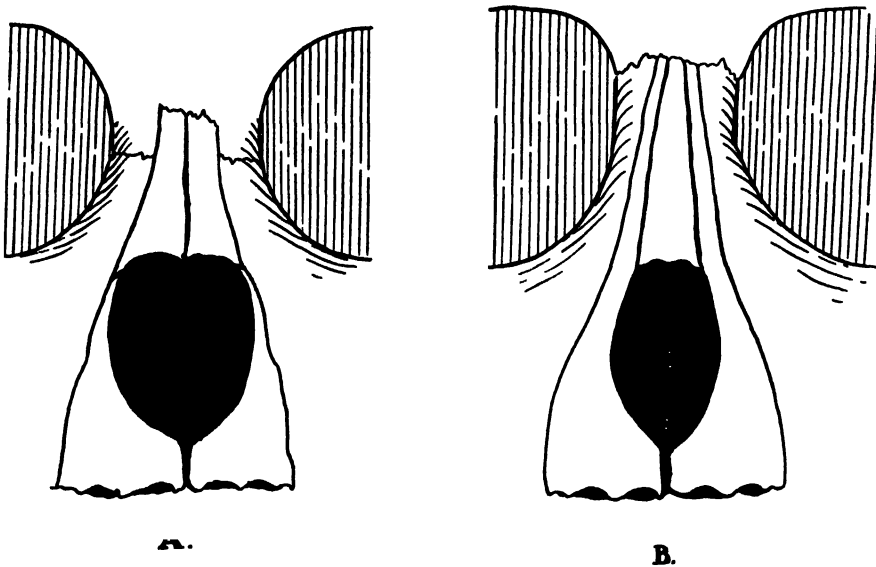


FIG. 8. THE ARTICULATIONS OF THE PREMAXILLA COMMON IN (A) NEW WORLD, AND (B) OLD WORLD MONKEYS—ACCORDING TO WOOD JONES
(After Wood Jones)

with the frontal bone at the fronto-nasal level.

With these statements my own observations may be compared.

Lemuroidea. In the Lemuroidea the short premaxillaries articulate narrowly with the infero-lateral borders of the nasal bones.

Callitrichidae. In the Callitrichidae the short premaxillaries are of two varieties, in the one the premaxilla articulates narrowly with the infero-lateral borders of

force, so it would seem, the whole or the greater part of the base of the nasal bones.

In *Pithecia satanas* and *Ateles geoffroyi* the premaxillaries just fail to meet the nasal bones.

In all species of *Cebus* the premaxillaries articulate narrowly at the supero-lateral angles of the pyriform aperture with the nasal bones.

In *Ateles palliata* and *Ateles ater* the premaxillaries articulate moderately broadly with the nasal bones infero-laterally.

In *Alouatta macconelli* the premaxillaries articulate moderately broadly, and in the remaining species narrowly, with the nasal bones infero-laterally.

With respect to *Lagothrix* Wood Jones takes objection to Forbes' 1894 (65) statement that "In regard to the skeleton, the skull of *Lagothrix*, as Dr. Slack points out, can be readily distinguished from that of the Capuchins by a broad, well-marked, articulation taking place between the premaxillary and the nasal bones at right-angles to the suture between the latter, while in the Capuchins no true articulation takes place between the bones." Wood Jones (100, p. 191) objects that "this is no distinction from *Cebus*, in which the same condition is present." In point of fact, however, there is here present a distinction between *Lagothrix* (together with *Pithecia pithecia*) and *Cebus*, for in the former genus the nasal portions of the premaxilla are quite broad, and often articulate with one another at the base of the nasal bones. In *Cebus*, on the other hand, the articulation with the nasal bones is narrow and the premaxillaries in this genus never approximate one another at the base of the nasal bones.

Thus, upon the basis of these observations, it may be said that in the Cebidae the relations of the premaxillary bones to the nasal bones vary in different genera and even between the species of the same genus. Thus, in *Pithecia satanas* and *Ateles geoffroyi* the premaxillaries just fail to meet the nasal bones, whilst in all species of *Cebus* and the majority of Alouattinae the premaxillaries articulate narrowly with them. In *Ateles palliata* and *ater*, and in *Alouatta macconelli* the articulation is moderately broad, whilst in *Lagothrix* and *Pithecia pithecia* the articulation is very broad.

The naso-maxillary bone

We may now turn to a consideration of the nasal relations in the Lasiopygidae, or as Wood Jones prefers to call this division of the primates, the Cynomorph Catarrhines. Wood Jones, as we have already seen, considers the common form of the premaxillary articulation in this Family to be with the frontal bone at and immediately lateral to the fronto-nasal junction. In a few genera of Old World Monkeys this seems to be the case, for example, in *Pithecia barbei* and in *Pygathrix germaini*, in the adult forms of which the premaxilla appears to establish a clear contact with the frontal as is the case in many lower mammals, or perhaps it may be more correct to say, as *appears* to be the case in lower mammals. For the examination of any infant Lasiopygid skull reveals the fact that what in adult specimens appears to be the elongated ascending process of the premaxilla establishing a clear contact with the frontal bone is in reality a distinct and independent bone only contiguously related to the premaxilla but not part of it. In adult specimens this bone becomes indistinguishably united to the ascending process of the premaxilla, its sutural junction with the latter being completely obliterated, so that in the adult it gives the appearance of being the continued projection of the ascending process of the premaxilla. Since this bone does not appear to have been described hitherto, and since it was consistently found in all young Lasiopygid crania examined, a description of it is here given from the skull in which it was first observed.

Erythrocebus whitei, ♀ A.M.N.H., No. 34710. Locality: British East Africa, Nasin Gishu, 7,200'. Third African Expedition—Rainsford. Oct. 26th, 1912.

Young female in which the deciduous dentition is alone present. All cranial sutures (with the exception of the frontal) are patent.

The premaxillary bones are seen as two distinct wedge-shaped bi-laterally symmetrical structures situated in the median plane between the palatine alveolar and facial portions of the maxillary bones. Each premaxilla consists of a body, which is situated facially subjacent and immediately lateral to the pyriform aperture, and two processes, a palatine and a naso-maxillary or ascending process, which

above the bridge or base of the nasal bones as the *pars facialis* of the premaxillary suture. Within the nasal fossa the *endo-facial* portion of the premaxillary suture, which is continuous with the exomesognathic portion of the premaxillary suture at the mid-lateral margin of the anterior naso-palatine foramen, proceeds superiorly upwards to the lateral angle at the bridge of the nose to meet the facial division of the suture. That part of the premaxilla adjacent to the nasal bones and representing the superior third of the premaxilla is the apical, ascending, or



FIG. 9. *ERYTHROCEBUS WHITEI*, INFANT, A.M.N.H. NO. 34710 SHOWING THE NASO-MAXILLARY BONE SITUATED BETWEEN THE NASAL BONE AND THE FRONTAL PROCESS OF THE MAXILLA

arise at right angles to one another from the body. The body is seen upon the facial aspect delimited from the maxilla by a suture which upon the palatine aspect arises from or is continuous with the exomesognathic division of the premaxillary suture, and proceeding laterally and slightly posteriorly, until it reaches to within the antero-lingual border of the canine alveolar ridge, passes between the lateral incisor and close to the canine alveolar septum, thus emerging upon the facial aspect whereon it continues superiorly and medially to meet the naso-maxillary suture lateral to and slightly

naso-maxillary process of the premaxilla. As will be seen from Fig. 9 the apex of the naso-maxillary process is for a short distance wedged between the infero-lateral border of the nasal bone and the medial border of the maxillary frontal process. Immediately above the apex of the naso-maxillary process of the premaxillary bone and articulating with it closely, as well as with the frontal process of the maxilla laterally, and with the nasal bone medially for about three-fourths of its length, is situated a narrow, somewhat fusiform-shaped bone maintaining a perfectly independent existence.

The bone above described was found to be present in all the infant and most of the young Lasiopygid crania examined, and was occasionally observed in the crania of mature individuals. This bone, which for want of a better name, we shall call the *naso-maxillary bone*, unites first with the apex of the naso-maxillary process of the premaxilla; the obliteration of the suture between it and the latter process in an adult skull would lead the observer unacquainted with the condition in the infant skull to assume that the elongate process which he observes to be continuous with the premaxilla actually represents the naso-maxillary process of the premaxilla. This is perhaps a pardonable error, but the fact is clearly otherwise. The naso-maxillary bone undoubtedly arises from a distinct ossification center of its own and in origin probably bears a close relation to the maxilla rather than to the premaxillary bone. It is not impossible that this bone represents the last vestige of one of the elements of the primitive vertebrate skull, but what this element may be it is at this stage unnecessary to venture a guess.

It is evident then, that the elongate naso-maxillary process which Wood Jones describes as commonly articulating with the frontal bone at the level of the fronto-maxillary junction in Old World Monkeys is actually an independent element contiguously associated with the premaxilla, but in origin not part of it.

Thinking that the presence of the naso-maxillary bone in the Lasiopygidae might possibly represent a new development, since it was not found among Primates lower than the Lasiopygidae, appearing for the first time in the Old World Monkeys, an examination of a new series of 42 infant crania of anthropoids was made, but in no case was any evidence of such an element found. In two young gorilla

and three young chimpanzee crania, an element of similar form and lying in the same relationship as the bone in the Lasiopygidae was found in each case on both sides of the skull. A much larger number of anthropoid skulls than we have in this connection been able to report upon will have to be examined, however, before it will be possible to say with what degree of frequency this element occurs in the anthropoid skull, for that it occurs in the anthropoid skull seems more than probable. Following the anthropoid

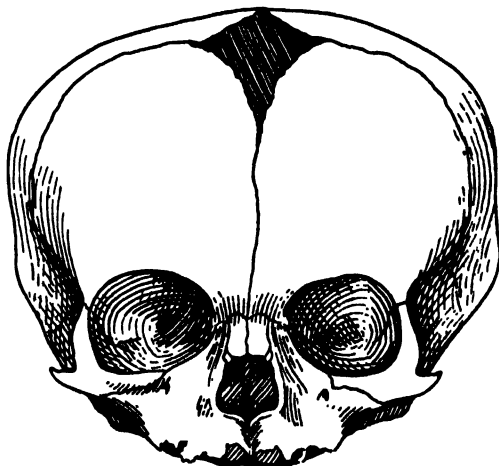


FIG. 10. NEWBORN HUMAN SKULL SHOWING THE PRESENCE OF THE NASO-MAXILLARY BONE ON EITHER SIDE OF THE SUPERIOR LATERAL ANGLES OF THE PYRIFORM APERTURE

crania, infant human crania were next examined, and interestingly enough the very first skull examined, a newborn of undetermined sex and race, showed a distinct small bone at each of the supero-lateral angles of the pyriform aperture situated between the maxilla and the infero-lateral angle of the nasal bone (See Fig. 10). In the very next skull examined, that of an infant Australian aboriginal of unknown sex and aged about 7 months, two such bones were similarly found to be present. The bone is relatively about one-third the length of the

naso-maxillary bone as it is represented in the Lasiopygidae and is relatively somewhat broader than in the latter family, but it, too, as in the Lasiopygidae tends to taper towards its extremities. It is difficult to resist the conclusion that this bone is none other than the homologue of that found among the Lasiopygidae.

In 21 additional white crania ranging in age between birth and 5 years of age, the naso-maxillary bone, or traces of it, was found in four cases, as follows: In a newborn; in the skull of a 4 months old infant; in the skull of a 3 year old infant on the right side only; and in the skull of a 5 year old child.

The examination of five cleared foetal human crania, ranging in age from 3 to 7 months, failed to reveal distinct evidences of the presence of this bone, although in two cases aged respectively 4 and 5 months a circumscribed rarified area in what appeared to be the infero-lateral angle of the nasal bone was observed. If this bone is at all constant in the human skull it is probably not completely ossified until birth or possibly shortly before, a fact which may account for the failure to observe it in these specimens; however, it is quite possible that the bone, vestigial as it undoubtedly is, only makes its appearance occasionally in man. It seems unnecessary to add that there is no legitimate reason to assume that the element here described is either an adventitious or a wormian bone.

The premaxilla in other Primates

We may now proceed with the description of the form of the premaxilla in the remaining Primates.

The terms used in the following summary description of the premaxillary, nasal, maxillary, and frontal, relations are to be interpreted as follows:

Short: The premaxillaries are short and do not reach the nasal bones.

Nasal: The premaxillaries just meet the infero-lateral margins of the nasal bones.

Slight Naso-Max: The premaxilla is inserted very slightly between the infero-lateral angle of the nasal bone and the maxilla.

Medium Naso-Max: The naso-maxillary process is inserted between the nasal bone and the maxilla for a distance about half way between the base of the nasal bones and the fronto-maxillary suture.

Long Naso-Max: The naso-maxillary process (apparently, but undoubtedly *not*, the premaxilla) which is inserted between the nasal bone and the maxilla just fails to meet the frontal bone at the fronto-maxillary suture.

Frontal: The naso-maxillary process, inserted between the nasal and maxillary bones, establishes contact with the frontal bone at the fronto-maxillary suture.

Naso-Max Bone: Naso-maxillary bone present.

An average of 65 skulls were examined for each species here noted. Unless otherwise stated all skulls belong to the *mature-adult* age group.

Papio papio, Slight Naso-Max.

Papio porcarius, Slight Naso-Max.

Papio hamadryas, Slight Naso-Max.

Papio cynocephalus, Slight Naso-Max.

Papio nigerias, Slight Naso-Max.

Theropithecus obscurus, Short. Nasal.

Cynopithecus niger, Long Naso-Max.

Pithecus rhesus, Nasal.

Pithecus nemestrinus, Nasal.

Pithecus brevicauda, Nasal.

Pithecus tibetanus, Nasal.

Pithecus cynomolgus, Medium Naso-Max.

Pithecus fascicularis, Medium Naso-Max.

Pithecus sinicus, Medium Naso-Max.

Pithecus mulatta, Slight, and Long Naso-Max.

Pithecus barbei, Frontal.

Lasiopyga diana (Infant), Naso-Max. Bone.

Slight Naso-Max.

Lasiopyga diana, Long Naso-Max.

Lasiopyga nictitans, Medium Naso-Max.
Lasiopyga stuhlmanni, Medium Naso-Max.
Lasiopyga callistruchus, Sights, and Long Naso-Max.
Lasiopyga cephus, Sights, and Long Naso-Max.
Lasiopyga dens, Medium and Long Naso-Max.
Lasiopyga petaurista, Medium, and Long Naso-Max.
Lasiopyga campbelli, Long Naso-Max.
Lasiopyga mona, Long Naso-Max.
Lasiopyga kolbe, Long Naso-Max.
Erythrocebus whistei (Infant), Naso-Max. Bone.
 Slight Naso-Max.
Erythrocebus whistei, Long Naso-Max.
Erythrocebus patas, Long Naso-Max.
Erythrocebus albigens, Long Naso-Max, and Nasal.
Pygathrix johnsi, Slight, and Medium Naso-Max.
Pygathrix germanus, Frontal.
Cercopithecus atterinus, Nasal Nasal.
Cercopithecus agilis, Slight Naso-Max.
Cercopithecus ursinus, Medium Naso-Max.
Colobus cottoni (Infant), Naso-Max Bone.
 Slight Naso-Max.
Colobus cottoni, Slight Naso-Max.
Colobus brunneus (Infant), Naso-Max Bone.
 Slight Naso-Max.
Colobus brunneus, Slight, and Long Naso-Max.
Colobus satanas (Infant), Naso-Max. Bone.
 Slight Naso-Max.
Colobus satanas, Long Naso-Max.
Colobus caudatus, Slight Naso-Max.
Colobus verus, Slight Naso-Max.
Colobus tebroceles, Long Naso-Max.

In the baboons of the genus *Papio* a naso-maxillary bone was not encountered once. In this genus the nasal bones are extremely narrow, so that if a naso-maxillary bone is present among them, which is doubtful, it is probably extremely rudimentary.

From our findings for the infant and adult members of *Lasiopyga diana*, *Erythrocebus whistei*, *Colobus satanas*, and *C. cottoni*, it should be quite clear that the ascending process of the premaxilla generally articulates but slightly with the nasal and maxillary bones, being inserted between them for but a short distance. The naso-maxillary bone, as a rule, unites with the ascending process of the premaxilla early in adult life, thus producing the appear-

ance of a prolonged ascending process of the premaxilla, the prolongation having in reality an origin quite independent of the premaxilla. Thus, when properly analysed, it transpires that the frontal and nasal relations of the premaxilla in the Lasiopygidae are substantially the same as in other Primates.

It is also of interest to note that whilst the naso-maxillary bone generally unites with the ascending process of the premaxilla, it also unites laterally quite frequently with the maxilla alone, as for example is the case in *Colobus brunneus* and *C. cottoni*. That this peculiarity of union, which seems to occur most regularly in the last two named species, not infrequently occurs in other genera and species is extremely likely.

It is apparent then, that the distinction drawn by Professor Wood Jones with respect to the premaxillary naso-frontal relations between the Old and the New World Monkeys, is excusably inaccurate.

With respect to the anthropoids, the African apes, the chimpanzee and the gorilla show a constant very slight naso-maxillary articulation of the premaxilla. Possibly the articulation is established by means of an attached naso-maxillary bone, but of this we have no actual evidence. In the Asiatic apes, the gibbon and the orang-utan, the articulation is variable, in some specimens the premaxilla just failing to meet the nasal bones whilst in others it establishes a slight contact with them.

In the human specimens showing the presence of the naso-maxillary bone, the premaxilla does not articulate with the nasal bone. Where a naso-maxillary bone was not observed as such the premaxilla establishes a very slight naso-maxillary contact.

In the constancy and form of the premaxillary-nasal relations the resemblance

GENUS	INFANT										YOUNG														
	Male					Female					Male					Female									
	No.	P	T	O	V	Percent O	No.	P	T	O	V	Percent O	No.	P	T	O	V	Percent O	No.	P	T	O	V	Percent O	
<i>Lemur</i>	6	6	—	—	—	0.0	1	1	—	—	—	0.0	41	39	3	—	—	0.0	24	23	—	1	—	—	4.1
<i>Callithrix</i>	1	1	—	—	—	0.0	1	1	—	—	—	0.0	8	8	—	—	—	0.0	9	8	1	—	—	—	0.0
<i>Midas</i>	1	1	—	—	—	0.0	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—	0.0
<i>Callicebus</i>	3	2	—	1	—	33.3	2	2	—	—	—	0.0	1	1	—	—	—	0.0	7	0	—	7	—	—	100.0
<i>Aotus</i>	1	1	—	—	—	0.0	3	3	—	—	—	0.0	2	2	—	—	—	0.0	7	6	1	—	—	—	0.0
<i>Pithecia</i>	5	5	—	—	—	0.0	7	7	—	—	—	0.0	4	4	—	—	—	0.0	4	4	—	—	—	—	0.0
<i>Samia</i>	6	2	—	4	—	66.6	11	8	—	3	—	27.2	11	4	2	6	—	50.0	19	7	2	10	—	—	52.6
<i>Alouatta</i>	10	10	—	—	—	0.0	18	18	—	—	—	0.0	17	17	—	—	—	0.0	18	18	—	—	—	—	0.0
<i>Ateles</i>	11	9	1	1	—	9.9	7	6	—	1	—	14.3	7	7	—	—	—	0.0	10	10	—	—	—	—	0.0
<i>Brachyteles</i>	1	1	—	—	—	0.0	1	1	—	—	—	0.0	1	1	—	—	—	0.0	2	2	—	—	—	—	0.0
<i>Lagothrix</i>	3	3	—	—	—	0.0	5	5	—	—	—	0.0	2	2	—	—	—	0.0	—	—	—	—	—	—	—
<i>Cebus</i>	18	14	2	2	—	11.1	13	11	1	1	—	8.4	34	14	4	16	—	47.0	40	16	4	10	—	—	50.0
<i>Colobus</i>	24	24	—	—	—	0.0	19	19	—	—	—	0.0	13	11	—	1	—	7.7	23	22	—	1	—	—	4.8
<i>Nasalis</i>	3	3	—	—	—	0.0	7	7	—	—	—	0.0	2	2	—	—	—	0.0	4	4	—	—	—	—	0.0
<i>Pygathrix</i>	10	10	—	—	—	0.0	37	37	—	—	—	0.0	11	11	—	—	—	0.0	31	30	—	1	—	—	3.2
<i>Erythrocebus</i>	115	113	2	—	—	0.0	106	103	1	2	—	1.9	41	39	1	1	—	2.4	84	75	5	4	—	—	4.7
<i>Lasiopygia</i>	68	67	1	—	—	0.0	78	76	1	1	—	1.3	61	59	2	—	—	0.0	70	68	1	1	—	—	1.3
<i>Coreocbus</i>	8	8	—	—	—	0.0	10	10	—	—	—	0.0	11	11	—	—	—	0.0	5	5	—	—	—	—	0.0
<i>Pithecia</i>	113	113	2	—	—	0.0	106	103	1	2	—	1.9	41	39	1	1	—	2.4	84	75	5	4	—	—	4.7
<i>Theropithecus</i>	2	2	—	—	—	0.0	2	2	—	—	—	0.0	4	4	—	—	—	0.0	—	—	—	—	—	—	—
<i>Cynopithecus</i>	—	—	—	—	—	—	7	7	—	—	—	0.0	2	2	—	—	—	0.0	3	3	—	—	—	—	0.0
<i>Papio</i>	14	14	—	—	—	0.0	10	10	—	—	—	0.0	34	34	—	—	—	0.0	45	45	—	—	—	—	0.0
<i>Symphalangus</i>	3	3	—	—	—	0.0	—	—	—	—	—	—	—	—	—	—	—	—	3	2	1	—	—	—	0.0
<i>Hylodactylus</i>	17	8	8	1	—	5.8	14	9	4	1	—	7.1	10	4	2	4	—	40.0	4	3	—	1	—	—	25.0
<i>Orang</i>	22	19	1	2	—	9.1	22	16	4	2	—	9.1	13	8	2	3	—	23.1	8	4	2	2	—	—	25.4
<i>Chimpanzee</i>	38	3	8	27	—	71.0	43	—	6	37	—	86.0	35	—	4	31	—	88.5	36	—	2	34	—	—	94.4
<i>Gorilla</i>	14	9	3	2	—	14.3	18	11	3	3	1	16.6	26	22	2	3	—	11.5	41	35	2	4	—	—	9.7
	406	340	16	40	—	9.8	436	364	10	51	1	11.7	405	318	22	65	—	16.0	502	395	21	86	—	—	17.1

between the African apes and man is singularly striking.

5. THE OBLITERATION OF THE MAXILLO-PREMAXILLARY SUTURE IN THE PRIMATES

In Table 1 will be found the particulars with respect to the degree of obliteration of the premaxillary suture in 5,277 sub-

human Primates arranged according to genus, age, and sex. The terms and symbols used in this Table have the following meaning:

Infant: Skulls in which the deciduous dentition is either partially or completely erupted, but in which no permanent tooth has erupted.

LE 1

Suture in the Primates

MATURE											ADULT											TOTAL NO.	TOTAL O	TOTAL PER CENT O		
Male					Female					Male					Female											
No.	P	T	O	V	Percent O	No.	P	T	O	V	Percent O	No.	P	T	O	V	Percent O	No.	P	T	O				V	Percent O
14	11	—	3	—	21.4	17	14	—	3	—	17.6	19	4	2	12	1	63.1	13	1	—	12	—	92.3	136	31	22.7
9	7	1	1	—	11.1	7	7	—	—	—	0.0	2	2	—	—	—	0.0	7	6	1	—	—	0.0	44	1	2.3
2	2	—	—	—	0.0	2	2	—	—	—	0.0	4	4	—	—	—	0.0	1	1	—	—	—	0.0	11	0	0.0
17	17	—	—	—	0.0	26	0	1	25	—	95.1	14	—	—	14	—	100.0	25	—	—	25	—	100.0	95	72	68.5
13	9	2	2	—	15.3	26	19	2	5	—	19.2	19	1	2	15	1	78.9	25	3	4	16	—	69.6	94	38	40.4
23	22	1	—	—	0.0	13	9	3	1	—	7.7	42	25	10	7	—	16.6	24	18	4	2	—	8.3	122	9	13.6
60	2	3	53	2	88.3	54	2	2	50	—	92.5	38	—	—	37	1	97.3	13	—	—	13	—	100.0	213	176	83.1
37	30	4	3	—	8.1	39	23	1	15	—	8.1	91	17	6	68	—	74.7	91	7	6	78	—	85.7	321	164	51.0
14	11	3	—	—	0.0	22	19	3	—	—	0.0	32	3	3	26	—	81.2	30	2	2	26	—	86.6	133	52	39.1
2	1	1	—	—	0.0	3	2	1	—	—	0.0	3	1	2	—	—	0.0	5	2	1	3	—	60.0	18	3	16.6
12	8	4	—	—	0.0	9	6	2	1	—	11.1	18	8	3	6	1	33.3	9	3	1	5	—	55.5	58	12	20.6
49	6	2	40	1	81.6	60	4	1	55	—	91.6	88	1	—	87	—	98.7	61	—	1	60	—	98.3	363	281	77.4
11	12	—	—	—	0.0	24	20	2	2	—	8.3	155	86	27	42	—	27.1	89	57	17	14	1	15.7	359	60	16.7
3	1	1	1	—	33.3	9	7	2	—	—	0.0	10	2	2	6	—	60.0	2	1	—	1	—	50.0	40	8	20.0
34	24	7	3	—	8.8	67	60	4	3	—	4.4	101	12	13	76	—	75.2	75	24	16	35	—	46.6	366	118	32.9
18	14	3	1	—	5.5	48	37	5	6	—	12.5	97	51	15	30	1	30.9	30	14	6	10	—	33.3	539	54	10.1
102	97	3	2	—	1.9	77	69	7	—	1	0.0	301	133	41	27	—	2.3	68	55	7	6	—	8.8	725	37	5.1
17	16	2	—	—	0.0	19	17	2	—	—	0.0	35	21	9	5	—	14.1	23	21	1	1	—	4.3	128	6	4.6
18	14	3	1	—	5.5	48	37	5	6	—	12.5	97	51	15	30	1	30.9	30	14	6	10	—	33.3	539	54	10.1
7	6	—	1	—	14.3	2	2	—	—	—	0.0	6	3	2	1	—	16.6	1	1	—	—	—	0.0	24	2	9.5
1	1	—	—	—	0.0	2	2	—	—	—	0.0	6	5	1	—	—	0.0	—	—	—	—	—	—	18	0	0.0
21	18	2	1	1	4.8	32	31	1	—	—	0.0	82	62	11	9	—	1.9	53	44	6	3	—	5.6	291	17	5.8
3	2	1	—	—	0.0	—	—	—	—	—	—	12	—	—	12	—	100.0	4	—	—	4	—	100.0	25	16	64.0
13	1	—	12	—	92.2	2	—	—	2	—	100.0	49	1	—	48	—	98.0	32	2	—	30	—	93.7	141	99	70.2
7	2	—	5	—	71.4	12	1	1	10	—	83.3	70	—	4	66	—	94.3	26	1	2	22	1	86.3	180	112	62.2
9	—	—	9	—	100.0	11	—	—	11	—	100.0	78	—	—	78	—	100.0	108	—	—	208	—	100.0	358	335	93.5
28	20	3	5	—	17.8	37	14	6	17	—	46.0	197	6	42	146	3	74.1	86	3	13	67	3	77.9	447	247	55.2
529	342	41	143	4	27.0	621	368	46	206	1	33.2	1477	456	195	818	8	55.3	901	267	88	541	5	59.0	5277	1851	35.2

Young: In which the third permanent molar is unerupted, and the basilar suture is open.

Mature: In which the complete permanent dentition is present and in an unworn condition, and the basilar suture is closed.

Adult: In which the dentition shows an

appreciable amount of wear, and beginning sutural union is present in two or more cranial sutures.

No.: Number of skulls examined.

P.: Premaxillary suture present in its entire extent.

T.: Premaxillary suture partially obliterated, traces present.

31

ture in the Primates

MATURE											ADULT											TOTAL NO	TOTAL O	TOTAL PER CENT O	
Male					Female					Male					Female										
P	T	O	V	Percent O	No	P	T	O	V	Percent O	No	P	T	O	V	Percent O	No	P	T	O	V				Percent O
11	—	3	—	21 4	17	14	—	3	—	17 6	19	4	2	12	1	63 1	13	1	—	12	—	92 3	136	31	22 7
7	1	1	—	11 1	7	7	—	—	—	0 0	2	2	—	—	—	0 0	7	6	1	—	—	0 0	44	1	2 3
2	—	—	—	0 0	2	2	—	—	—	0 0	4	4	—	—	—	0 0	1	1	—	—	—	0 0	11	0	0 0
17	—	—	—	0 0	16	0	1	25	—	95 1	14	—	—	14	—	100 0	25	—	—	25	—	100 0	95	72	68 5
9	2	2	—	15 3	26	19	2	5	—	19 2	19	1	2	15	1	78 9	25	3	4	16	—	69 6	94	38	40 4
22	1	—	—	0 0	13	9	3	1	—	7 7	41	25	10	7	—	16 6	24	18	4	2	—	8 3	122	9	13 6
2	3	53	2	88 3	54	2	2	50	—	92 5	38	—	—	37	1	97 3	13	—	—	13	—	100 0	213	176	83 1
30	4	3	—	8 1	39	23	1	15	—	8 1	91	17	6	68	—	74 7	91	7	6	78	—	85 7	321	164	51 0
11	3	—	—	0 0	22	19	3	—	—	0 0	32	3	3	26	—	82 2	30	2	2	26	—	86 6	133	52	39 1
1	1	—	—	0 0	3	2	1	—	—	0 0	3	1	2	—	—	0 0	5	1	1	3	—	60 0	18	3	16 6
8	4	—	—	0 0	9	6	2	1	—	11 1	18	8	3	6	1	33 3	9	3	1	5	—	55 5	58	12	20 6
6	2	40	1	81 6	60	4	1	55	—	91 6	88	1	—	87	—	98 7	61	—	1	60	—	98 3	363	281	77 4
12	—	—	—	0 0	24	20	2	2	—	8 3	155	86	27	42	—	27 1	89	57	17	14	1	15 7	359	60	16 7
1	1	1	—	33 3	9	7	2	—	—	0 0	10	2	2	6	—	60 0	2	1	—	1	—	50 0	40	8	20 0
24	7	3	—	8 8	67	60	4	3	—	4 4	101	12	13	76	—	75 2	75	24	16	35	—	46 6	366	128	32 9
14	3	1	—	5 5	48	37	5	6	—	12 5	97	51	15	30	1	30 9	30	14	6	10	—	33 3	539	54	10 1
97	3	2	—	1 9	77	69	7	—	1	0 0	201	133	41	27	—	2 3	68	55	7	6	—	8 8	725	37	5 1
16	1	—	—	0 0	19	17	2	—	—	0 0	35	21	9	5	—	14 2	23	11	1	1	—	4 3	128	6	4 6
14	3	1	—	5 5	48	37	5	6	—	12 5	97	51	15	30	1	30 9	30	14	6	10	—	33 3	539	54	10 1
6	—	1	—	14 3	2	2	—	—	—	0 0	6	3	2	1	—	16 6	1	1	—	—	—	0 0	24	2	9 5
1	—	—	—	0 0	2	2	—	—	—	0 0	6	5	1	—	—	0 0	—	—	—	—	—	—	18	0	0 0
18	1	1	1	4 8	32	31	1	—	—	0 0	82	62	11	9	—	1 9	53	44	6	3	—	5 6	291	17	5 8
2	1	—	—	0 0	—	—	—	—	—	—	12	—	—	12	—	100 0	4	—	—	4	—	100 0	25	16	64 0
1	—	12	—	92 2	2	—	—	2	—	100 0	49	1	—	48	—	98 0	32	2	—	30	—	93 7	141	99	70 2
2	—	5	—	71 4	12	1	1	10	—	83 3	70	—	4	66	—	94 3	26	1	2	22	1	86 3	180	112	62 2
—	—	9	—	100 0	11	—	—	11	—	100 0	78	—	—	78	—	100 0	108	—	—	108	—	100 0	358	335	93 5
20	3	5	—	17 8	37	14	6	17	—	46 0	197	6	42	146	3	74 1	86	3	13	67	3	77 9	447	247	55 2
141	41	143	4	27 0	621	368	46	206	1	33 2	1477	456	195	818	8	55 3	901	267	88	541	5	59 0	5277	1851	35 2

Young: In which the third permanent molar is unerupted, and the basilar suture is open.

Mature: In which the complete permanent dentition is present and in an unworn condition, and the basilar suture is closed.

Adult: In which the dentition shows an

appreciable amount of wear, and beginning sutural union is present in two or more cranial sutures.

No.: Number of skulls examined.

P.: Premaxillary suture present in its entire extent.

T.: Premaxillary suture partially obliterated, traces present.

O.: Premaxillary suture completely obliterated in its entire extent.

V.: Variant forms of obliteration.

Per Cent O.: Percentage of skulls in which the premaxillary suture is completely obliterated.

+*R-L.*: Premaxillary suture present on right, obliterated on left side.

+*L-R.*: Premaxillary suture present on left, obliterated on right side.

TR-L.: Traces of premaxillary suture on right, obliterated on left side.

TL-R.: Traces of premaxillary suture on left, obliterated on right side.

+*RTL.*: Premaxillary suture present on right, traces only on left side.

All percentages refer to complete obliterations of the premaxillary suture. Skulls in which *traces* of the suture were present are recorded separately.

It should be noted here that all skulls displaying signs of an advanced age, more particularly as exhibited in the general obliteration of the cranial sutures, were excluded from the series recorded in Table 1 as tending to give a false weight to the percentage of obliteration of the premaxillary suture in the adult group.

Lemuroidea

In the Lemuroidea it appears that the premaxillary suture begins to show signs of obliteration as early as the period of youth. In 7.1 per cent of young males the suture was found to be in various stages of obliteration, whilst in 4.1 per cent of females the suture was completely obliterated. Following the period of youth the suture undergoes a progressive obliteration until, in the female adult 92.3 per cent of crania show a complete absence of any trace of the suture. Thus, 22.7 per cent of the total number of Lemurs examined showed complete obliteration of the premaxillary suture.

Callitrichidae

In the Callitrichidae a mature skull of *Callithrix* showed complete obliteration of the suture, that is, 11.1 per cent of mature males, or 2.3 per cent of the total number examined (44 crania).

Eleven skulls of *Midas* were examined and these all showed the unobliterated suture.

In *Callicebus*, which may be regarded in this as in other respects as the most advanced of the Callitrichidae, a surprisingly high percentage of crania show complete obliteration of the premaxillary

TABLE 2

The Obliteration of the Premaxillary Suture in the Primates

FAMILY	NO EXAMINED	OBLITERATED IN	PERCENT OBLITERATED IN
Lemuroidea	136	31	22.7
Callitrichidae . . .	150	73	48.6
Cebidae ..	1322	735	55.6
Lasiopygidae .	2518	203	7.6
Hylobatidae	166	115	69.3
Anthropomorphae	985	694	70.4
	5277	1851	35.2

suture, viz. in 33.3 per cent of infant males, 100.0 per cent of young females, 95.1 per cent of mature females, and in 100.0 per cent of mature adults. Total obliterations, 68.5 per cent.

Of all Callitrichidae examined 48.6 per cent showed complete obliteration of the premaxillary suture.

Cebidae

In the Cebidae the premaxillary suture tends to become obliterated fairly early in post-natal development, thus, 12.7 per cent of male and 7.7 per cent of female infants of this family exhibit the suture completely obliterated.

Aotus shows beginning obliteration first

in a young female, or in 11.1 per cent of young, when after there is a gradual increase in the frequency of obliterations until 73.8 per cent of adults show complete obliteration of the suture. The total obliterations were 40.4 per cent.

In *Pithecia* partial obliteration is found first in about 11.1 per cent of mature individuals, and complete obliteration in only 2.8 per cent of the same group. Adults showed complete obliteration in 10.3 per cent of cases only, males showing exactly twice as many obliterations as females. The suture was thus found obliterated in a total of 13.6 per cent of cases.

In *Saimiri* the premaxillary suture was found completely obliterated in 41.2 per cent of infants, in the proportions of 66.6 per cent of males and 27.2 per cent of females. This represents a somewhat remarkable finding for a Cebid monkey, since with the exception of the chimpanzee (70.9 per cent of obliterations in the infant) no other sub-human primate exhibits anything approaching as high a frequency of obliteration of this suture in infancy, unless it be *Callicebus* with 33.3 per cent of infant obliterations (3 cases examined only). The tendency toward obliteration of the premaxillary suture is maintained and markedly displayed in the older series, adults showing a frequency of obliteration of 98.0 per cent. Of all Saimiridae 83.1 per cent show complete obliteration of the suture, a percentage that is exceeded only by the chimpanzee with 93.5 per cent.

In *Alouatta* partial and complete obliteration is first observed in the mature group, 23.7 per cent of the mature crania showing complete obliteration, the females with 35.8 per cent showing four times as many obliterations as the males with 8.1 per cent. The adults show a fairly high proportion of obliterations, viz. 80.2 per

cent, the females with 85.7 per cent showing a slightly higher percentage than the males with 74.7 per cent. The total number of obliterations in the Alouattinae was 51.0 per cent.

In *Ateles* the somewhat bewildering observation that 11.1 per cent of infants exhibit complete obliteration of the premaxillary suture whilst no other age group up to the adult displays a similar condition must be accounted merely one of the vagaries of the quantitative method of investigation, particularly since the number of cases examined in each age group was by no means as exhaustive as one could have wished (total 133). *Partial* obliteration occurs in an infant male, or in 9.9 per cent of infants, and subsequently is again observed in 16.6 per cent of mature cases, whilst 83.3 per cent of adults show complete obliteration, the females with 86.6 per cent slightly predominating over the males with 81.2 per cent. A total of 39.1 per cent of Atelinae show complete obliteration of the premaxillary suture.

Only 18 skulls of *Brachyteles* were examined. Beginning obliteration is first observed in 40.0 per cent of mature crania, and complete obliteration in 60.0 per cent of adult females. Of the total number 16.6 per cent thus show complete obliteration. These figures are probably not strictly reliable owing to the small number of Brachytelid skulls examined. In *Lagothrix* the infant and young skulls showed the suture perfectly patent. In the mature group 30.0 per cent of the males and 22.2 per cent of the females show *partial* obliteration, whilst only the females show complete obliteration in 11.1 per cent of cases. Of adults 40.7 per cent show complete obliteration. In *Lagothrix* a total of 20.6 per cent of cases show complete obliteration of the premaxillary suture.

Cebus shows a relatively high proportion of complete obliterations for all ages, thus, 9.7 per cent of infants, 48.6 per cent of young, 87.0 per cent of mature, and 98.6 per cent of adults,—a total of 77.4 per cent showing complete obliteration of the premaxillary suture.

For the Cebidae as a whole then, 735 skulls out of a total of 1322, or 55.6 per cent show complete obliteration of the premaxillary suture.

Lasiopygidae

The Lasiopygidae exhibit a quite surprisingly small number of obliterations of the premaxillary suture, showing a frequency of only 7.6 per cent of obliterations, which is by far the lowest for all the Primates examined, and is exactly two-thirds lower than the frequency for the Lemuroidea, which we found to be 22.7 per cent. With the exception of *Colobus* with 16.7 per cent, *Nasalis* with 20.0 per cent, and *Pygathrix* with 32.9 per cent of obliterations, the remaining seven genera of Lasiopygidae examined show a frequency of obliteration never exceeding 10.1 per cent. Now, it is an interesting fact that the three genera just named all belong to the Semnopithecus division of the Lasiopygidae, a group which is separated by numerous characters from the remaining Lasiopygidae here considered, namely, the Cercopithecinae. This observation offers a possible clue to the determination of the probable factor responsible for the more frequent obliteration of the premaxillary suture in certain genera and not in others. This clue is suggested by the fact that the Semnopithecus in question exhibit a total of 24.3 per cent of obliterations, whilst the Cercopithecus exhibit only 6.6 per cent of obliterations, a frequency three-fourths less than that of the Semnopithecus. Now, the Semnopithecus possess very

short muzzles, whereas the Cercopithecus possess muzzles which are generally elongate, in the Cynomorphae being very produced; these facts may point to a significant correlation between the form of the muzzle and the frequency of obliteration of the premaxillary suture. The detailed analysis of these characters in the Lasiopygidae yields the following results:

Very Short Muzzle.

	Per Cent of Obliterations
<i>Colobus</i>	16 7
<i>Nasalis</i>	20 0
<i>Pygathrix</i>	32 9
Average	24 3

Slightly Elongate Muzzle.

	Per Cent of Obliterations
<i>Cercopithecus</i>	4 6
<i>Lasiopyga</i>	5 1
<i>Ptilopus</i>	10 1
Average	6 9

Moderately Elongate Muzzle.

	Per Cent of Obliterations
<i>Erythrocebus</i>	3 5
<i>Theropithecus</i>	9 5
Average	5 7

Very Elongate Muzzle.

	Per Cent of Obliterations
<i>Cynopithecus</i>	0 0
<i>Papio</i>	5 8
Average	5 5

From these figures it would seem that there is in general a slight tendency for long-muzzled forms to display a greater frequency of unobliterated premaxillary sutures than in the shorter muzzled forms. The significant fact is, however, that all the Cercopithecus have more or less produced muzzles, whereas none of the remainder of the Primates here considered, with the exception of the lemurs, possess such prolonged muzzles. The comparatively high frequency of obliterations in the lemurs, 22.7 per cent, is explained by the fact that the lemur skull

undergoes a very early general synostosis which causes its sutures, with one or two exceptions, to disappear quite early in post-natal development. From all this there can be little doubt that the premaxillary suture tends to persist in long-muzzled Primates; and from our other observations, in association with this last, we may, I think justifiably, draw the general inference that the premaxillary suture tends to undergo a more frequent obliteration with the progressive reduction of the snout.

Anthropoids

The anthropoids exhibit a variably high frequency of obliterations of the premaxillary suture.

Only 25 skulls of *Symphalangus* were examined, 64.0 per cent of which showed complete obliteration of the premaxillary suture.

Of *Hylobates* 141 skulls were examined, and of these 70.2 per cent showed complete obliteration of the premaxillary suture, as follows: 7.4 per cent of infants, 35.7 per cent of young, 93.3 per cent of mature, and 96.3 per cent of adults. Similar figures would probably have been obtained for *Symphalangus* had an equal number of skulls been examined.

The orang shows 62.2 per cent of complete obliterations, as follows: 9.1 per cent of infants, 23.8 per cent of young, 79.0 per cent of mature, and 91.6 per cent of adults.

The chimpanzee shows the highest frequency of obliterations of any of the anthropoids or any of the Primates with the exception of man, namely, 93.5 per cent of complete obliterations. In my series of chimpanzees the premaxillary suture is completely obliterated in 79.0 per cent of infants, within which group are included seven newborn skulls of which two showed complete obliteration

of the suture, that is, 28.6 per cent of newborns. The suture is completely obliterated in 91.5 per cent of young, and in 100.0 per cent, respectively, of mature and adult individuals, (See fig. 11).

The gorilla, curiously enough, shows the lowest frequency of obliterations, namely, 55.2 per cent, distributed as follows: Infant, 15.6 per cent; young, 10.4 per cent; mature, 33.8 per cent; and adult, 75.2 per cent. The drop from 15.6 per cent of obliterations in the infant to 10.4 per cent in the young must be considered as due once more to the vagaries of the inadequate simple quantitative method of evaluating results.

The three great apes show, altogether, a total frequency of obliterations of 70.4 per cent.

Summarised the detailed results for the frequency of obliteration of the premaxillary suture in the anthropoids are as follows:

	<i>Gibbon</i>	<i>Orang</i>	<i>Chimpanzee</i>	<i>Gorilla</i>
Infant.....	7.4	9.1	79.0	15.6
Young.....	35.7	23.8	91.5	10.4
Mature.....	93.3	79.0	100.0	33.8
Adult.....	96.3	91.6	100.0	75.2
Total.....	70.2	62.2	93.5	55.2

In Fig. 11 these results are graphically expressed. It will be observed that in the chimpanzee by the period of youth the premaxillary suture is almost invariably obliterated, only 21.0 per cent of infant and 8.5 per cent of young showing the presence of the suture. No other anthropoid shows anything approaching so high a frequency of obliteration either in infancy or youth, whilst for the mature group only the gibbon approaches the chimpanzee with 93.3 per cent of complete obliterations, the next in order being the orang with 79.0 per cent.

Why the premaxillary suture should tend to persist latest in the gorilla, which is the least prognathous of the apes, I am

at a loss to understand, unless the explanation be found in the heavy development of the anterior teeth, which are quite obviously subject to far heavier stresses than is the case in the other apes.

In the primates as a whole it would appear that there is a slight sexual varia-

tion from below upwards, commencing first at the antero-inferior alveolar margin and proceeding upwards until the apical portion of the premaxillary suture is finally obliterated.

Man

With respect to the post-natal human material hereunder referred to, 4,632 skulls ranging between the ages of 6 to 60 years were examined, comprising altogether some 42 of the races of mankind. In not one of these skulls was the slightest trace of a premaxillary suture found upon the face, though endofacially the suture was seen in about 25.0 per cent of cases. We have already seen that traces of the suture may sometimes be found at the inferior naso-maxillary junction, upon the face, up to the end of the fifth year, thereafter, it appears, not the slightest trace of a suture is to be observed.

From what we know of the premaxillary naso-maxillary relations upon the facial aspect of the skull, and the peculiarities of development in this region, it seems certain that in a large proportion of the lower races of mankind and in a fair number of Caucasian crania, the premaxilla remains unobscured upon the face towards its junction with the infero-lateral border of the naso-maxillary bone, or if the existence of the naso-maxillary bone is doubtful, with the infero-lateral border of the nasal bone. The independence of the premaxilla here is, of course, lost, but that a small apical area of it remains unobscured upon the face in a large number of crania seems to me rendered certain by my observations upon the development of this region in foetal and infant human crania. Certain it is, too, that in almost all human crania the supero-lateral borders of the pyriform aperture are formed by the premaxillary bones alone.

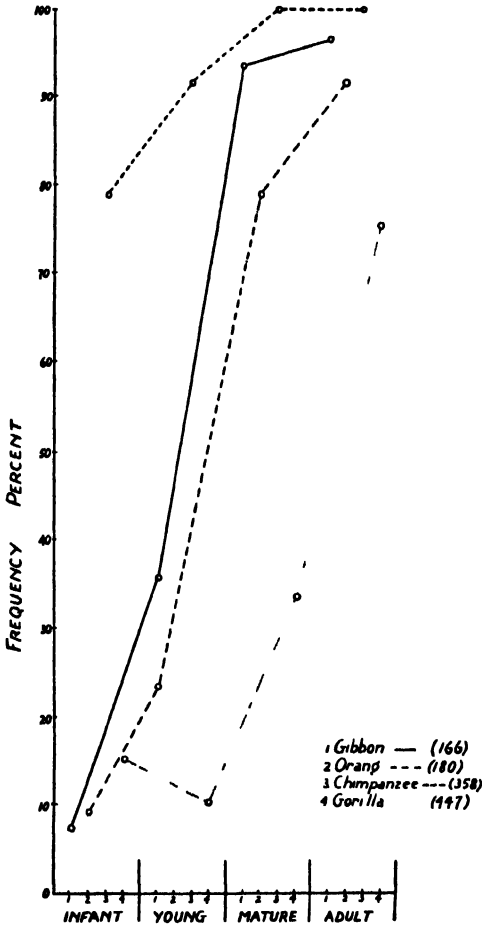


FIG. 11. GRAPH SHOWING THE FREQUENCY OF OBLITERATION OF THE PREMAXILLARY SUTURE IN THE ANTHROPOIDS

tion in favor of the female for the premaxillary suture to undergo obliteration earlier and somewhat more frequently than in the male.

As for the manner of obliteration, this is always interstitial and invariably proceeds

6. CONCLUSIONS

The purpose of this study has now been achieved. The form, structure, and relations of the premaxilla in the Primates have been described, and the peculiar form and structure of the human premaxilla, here for the first time clearly demonstrated, accounted for. It has been shown that the form of the premaxilla in man is due to a perfectly comprehensible structural adaptation which has of necessity followed upon the extreme reduction in the importance of the oral, olfactory, and dental functions, which has found expression in the associated reduction of the oral-olfactory-dental apparatus in man,—in the great shrinkage of the premaxilla anteriorly, a shrinkage which may be said to have completely reduced the anterior projection of the face. We have seen that the sub-pyriform facial portion of the body of the premaxilla has, in man, completely disappeared and been replaced by the maxilla, which now contributes the greater part of the bony support for the four maxillary incisors. The central incisors are the first teeth to erupt in the upper jaw; the site of their development must therefore be early completed, and the whole region in which they develop early stabilized, and this we find to be the case. In development therefore, the process of embracement of the premaxilla by the maxilla commences first inferiorly and terminates finally upon the nasomaxillary process. It has been shown, however, that the terminal embracement of the premaxilla is often incomplete, as may be determined by the careful examination of the apical portion of the nasomaxillary process of the premaxilla in newborn and occasionally, in infant human crania. Often a suture between the maxilla and the apical premaxilla may be

clearly observed upon the facial aspect of such skulls; if this suture is carefully examined it is seen to be none other than the facial portion of the premaxillary suture, proving that even upon the facial aspect of the human skull all anthropoid traits with respect to the premaxilla are not yet fully obliterated.

In such races of mankind in which the projection of the jaws is still somewhat pronounced (exemplified in this study by the negro), the premaxilla appears to be somewhat larger than in the more orthognathous races, and tends to undergo obliteration appreciably later. This fact is in complete harmony with the finding that in the sub-human Primates, with one or two exceptions, the premaxillary suture invariably undergoes obliteration much earlier in life in the shorter-muzzled than in the longer-muzzled forms, thus, for example, the Cynomorphae or dog-faced baboons exhibit a significantly far smaller number of obliterations of this suture than do the shorter-muzzled Cebidae. Likewise, negro foetuses show the premaxillary suture more frequently patent apically and endofacially than do white foetuses of similar age.

Without entering further upon the reasons, we may say then, that in general the smaller the size of the premaxilla, the sooner is its union with the maxilla effected. In man, in whom this bone is relatively smaller than it is in any other animal, the union commences, though it is not completed until long after, at a very early period, at about the end of the third foetal month. It would appear then, that early maxillary-premaxillary union is correlated with the size of the premaxilla. This does not necessarily mean that the size of the premaxilla determines the period at which the latter's independence is lost, but, rather as is more

likely, that these two factors are together determined by a series of others, such as the size of the anterior teeth, and the degree of development of the oral-olfactory senses. In this connection it is important to note that the period at which the size of the premaxilla was acquired in the evolutionary development of any particular Primate is of no consequence whatsoever; whether early or late in the phylogenetic development of the species, the period in the ontogenetic development of the individual at which the union of the premaxilla with the maxilla takes place is dependent entirely on what Wood Jones has dismissed as certain "grounds of expediency in development," and these have already been stated above.

Surely, in view of the facts which have here been brought to light, it is quite unnecessary, not to say undesirable, to make an appeal to the so-called Biogenic Law, as Wood Jones does, in order to explain in man the early commencement of the "merging" of the premaxilla in the maxilla? It is difficult to see how matters could be otherwise if by "merging" we understand more correctly "enclosure" or "embracement," for the premaxilla preserves a great part of its structural independence from the maxilla until well after birth, so that there is here actually no question of merging, but, instead, merely a matter of masking, which is a very different thing. The reasons for this have already been stated. It is in this peculiar masking of the premaxilla by the maxilla in man that a feature of specific value may be recognised, and with these modifications the recognition of it is entirely due to Professor Wood Jones.

The alleged differences between the Old and the New World Monkeys with respect to the frontal relations of the premaxilla have been shown to be non-existent, but to be due rather to the

presence of an interpolated element occurring in the skull of all Old World Monkeys; this bone has been called the *nasomaxillary bone*, and has been shown to be only *contiguously* related to the premaxilla, being in origin in no way part of it. The homologous element has also been demonstrated for a few cases in man, and possibly the chimpanzee and the gorilla; its presence in all African ape and human crania is doubtful, and it is perhaps better to assume for the time being that this element is only occasionally present in these groups.

The strong retrogressive trend of the premaxilla in man is reflected in the great frequency with which it is disordered. Cleft-palate and hare-lip, complete or partial absence of the incisor teeth, especially of the lateral incisors, supernumerary teeth, eversion of the canine with contact of the lateral incisors and the first premolar, twisted and tilted incisors, decrease in the breadth of the nose, with crowding of the nasal septum, decrease in the inter-orbital breadth, and shortening of the upper lip, these are some of the better-known conditions which may be regarded as due to this retrogressive trend affecting the premaxilla.

Congenital absence and reduction of the lateral incisors occurs among a few sub-human Primates (117, 118), but with nothing like the frequency with which it occurs in man in whom it is to be regarded as the result of the fact that the region in which these teeth normally develop, namely, the postero-lateral portions of the premaxilla, represent areas of great instability in consequence of their intensive reduction.

7. SUMMARY

1. The purpose of this study has been to determine whether or not the alleged early obliteration of the facial division

between the maxillary and premaxillary bones, in man, may be regarded as a definite human specific character. The detailed anatomy of the human premaxilla is reserved for a future study.

2. The form, structure, and relations of the premaxilla, and the period of obliteration of the facial portion of the premaxillary suture in man and the sub-human Primates have been examined and determined in approximately 10,000 crania including some 42 of the less frequently reported upon races of mankind.

3. It has been shown that the form of the premaxilla in man at the end of the third foetal month is almost identical in form with that of the anthropoids; that, immediately after the end of the third foetal month the anterior wall of the body of the premaxilla becomes overgrown by the lateral plates of the maxilla, and is, with the exception of the anterior nasal spine and the inferior portions of the pyriform aperture, completely absorbed and replaced by them. It is in this peculiar process of obliteration of the facial portion of the premaxilla in man that a character of a specific nature may alone be recognised.

4. The peculiar involution of the premaxilla in man is shown to be a necessary adaptation following upon the extreme reduction of the olfactory and oral senses, in association with the great reduction in the size of the anterior teeth.

5. It has been shown that the apical portion of the premaxilla may be observed upon the facial aspect of the late foetal and infant human skull in a fair proportion of cases quite clearly separated from the maxilla by a distinct suture. In skulls exceeding six years of age the suture is never to be observed facially, though it may be seen endofacially, to a greater or less extent, in some 26 per cent of cases.

6. It has been shown that in the Primates as a whole the period at which the premaxillary suture tends to undergo obliteration is correlated with the size of the premaxilla; the smaller the size of the premaxilla the earlier does the suture tend to undergo obliteration. Thus, negro foetuses, which are distinctly more prognathic than white foetuses, show a strong tendency for the remains of the premaxillary suture to remain unobliterated for a greater period of time than in the more orthognathous white foetuses. The early union of the maxilla with the premaxilla is in no way connected with the period in the phylogenetic history of the species during which the peculiar characters of the premaxilla were acquired, but is the expression, rather, of early functional demands.

7. The naso-maxillary relations of the premaxilla are described, and it has been shown that they are substantially the same in all Primates, including man.

8. A hitherto unrecognised, but constantly found, bone situated at the apex of the ascending or naso-maxillary process of the premaxilla, between the nasal bone medially and the frontal process of the maxilla laterally, in infant-young Old World monkeys is described as the *naso-maxillary bone*. Ignorance of the existence of this bone has led to the inaccurate description of the frontal relations of the premaxilla in Old World monkeys. This bone is also described in a few young human crania. It is considered to be the vestigial homologue of the similar element in Old World monkeys. It was not found in anthropoids, though it may be present in them.

9. A review of the literature dealing with the premaxilla is provided.

LIST OF LITERATURE

- 1 EPHESUS, RUFUS OF 1554 De Appelationibus Partium Corporis Humani, Lib III, c 1, *Parrhissus*
- 2 GALEN, C 1535 De Ossibus ad Tirones, *Lyons*
- 3 ——— 1550 De Natura Ossium, Cap 3, p 14, *Parrhissus*
- 4 SYLVIVS, J 1536 Galenique Rem Anatomica, p 6, *Parrhissus*
- 5 VESALIUS, A 1543 De Humani Corporis Fabrica, Lib 1, Cap 9, pp 36-43, *Basslea*
- 6 ——— 1546 Epistola Rationem Modumque Propinandi, etc, *Basslea*
- 7 SYLVIVS, J 1551 Vacani Cuiusdam Calumniarum in Hippocratis, *Parrhissus*
- 8 COLUMBUS, R C 1559 De Re Anatomica, Lib 1, Cap 8, p 30, *Basslea*
- 9 FALLOPIUS, G 1561 Observationes Anatomicae, p 35, *Veneti*
- 10 VESALIUS, A 1562 Observationum Falloppii Examen, *Basslea*
- 11 INGRASSIAS, L 1603 Commentarii in Galeni Librum de Ossibus, *Panorm*
- 12 RIOLAN, J 1610 Anatome Corporis Humani, Cap 24, pp 48-50, *Parrhissus*
- 13 SPIGEL, A 1626 De Formato Foetu, p 53, *Padone*
- 14 EYSSON 1699 Tractatus Anatomicam et Medicam de Ossibus Infantis, vol 2, p 487, *Geneve*
- 15 TYSON, E 1699 Orang-outang, sive Homo sylvestris, p 68, *London*
- 16 NEBBITT, R 1736 The Human Osteology, p 195, *London*
- 17 ALBINUS, B S 1737 De ossibus corporis humani, pp 53-61, *Leiden*
- 18 DAUBENTON, E L 1764 La situation du grand trou occipital, etc, *Hist de L Acad Roy des Scs de Paris*, pp 568-575
- 19 BLUMENBACH, J F 1776 De Generis Humani Varietate Nativa, pp 33-34, *Gotttingae*
- 20 CAMPER, P 1778 Kurze Nachricht von der verschiedener Orang utange, Kleinere Schriften, vol 1, Pt 2, pp 93-94, *Leipzig*
- 21 D AZYR, VICQ F 1780 Observations Anatomiques sur Trois Singes, etc, *Hist de L Acad Roy des Scs de Paris*, pp 478-493
22. GÖTTE, W 1786 Dem Menschen wie den Thieren ist ein Zwischenkiefer den oben Rinnlade zuzuschreiben, *Jena*
- 23 SOMMERING, S T 1794 De Corporis Humani Fabrica, vol 1, pp 144-152
- 24 FISCHER, G. 1800 Ueber die verschiedene Form der Intermaxillarknochen in verschiedenen Thieren, *Leipzig*
- 25 ROSENUELLER, J C 1804 Diss de Singularibus et Nativis Ossium Corporis Humani Varietatibus, p 14, *Leipzig*
- 26 BLUMENBACH, J F 1807/1827 A Manual of Comparative Anatomy, translated from the German of J F Blumenbach, with additional note, by William Lawrence, Esq, F R S, 1807, Second edition, revised and augmented, by William Coulson, pp 17-19, *London*
- 27 GÖTTE, W 1835 Briefe an Merck, p 466, *Darmstadt*
- 28 MECKEL, J F 1838 Manual of Descriptive and Pathological Anatomy, p 67, *London*
- 29 LEUCKART, K G 1840 Untersuchungen über das Zwischenkieferbein des Menschen, *Struttgart*
- 30 LAWRENCE, W 1844 Lectures on Comparative Anatomy, pp 119-120, *London*
- 31 LEIDY, J 1849 On the existence of the intermaxillary bone in the embryo of the human subject, *Proc Acad Nat Sci Philadelphia*, vol 5, No 7, pp 145-147
- 32 PREIL, C R 1849 Ueber die Zwischenkieferknochen *Wurzburg*
- 33 LAMMERS, P 1853 Ueber das Zwischenkieferbein des Menschen, u s w, *Erlangen*
- 34 HUMPHRY, G M 1858 A Treatise on the Human Skeleton, p 182, p 283, *Cambridge*
- 35 BRYANT, T 1858/59 Necrosis of the intermaxillary bones, *Trans Path Soc London*, pp 216-217
- 36 ROUSSEAU, E 1858/59 De la non-existence de los intermaxillaire chez l homme à l etat normal C R de L Acad des Scs, T XLVII, p 46, p 176, & p 260
- 37 SALTER, J 1860 Exfoliations of portions of the maxillary bones with contained teeth, etc, *Trans Path Soc London*, Vol XI, pp 209-215
- 38 CLELAND, J 1861 On the relations of the vomer, ethmoid, and intermaxillary bones, *Proc Roy Soc London*, vol XI, pp 163-166
- 39 JACKSON, H 1862 Case of exfoliation of one of the premaxillary bones after measles, *Med Times & Gazette*, vol 2, pp 681-682
- 40 LEWES, G H 1864 The Life of Goethe, *London*, pp 345-350
- 41 BRYANT, T 1864 Exfoliation of the intermaxillary bones of an adult, *Lancet*, vol 2, p 153

42. VOGT, C 1864 Lectures on Man, pp 147-148, *London*
43. SMITH, J 1866 On certain points in the morphology of cleft palate, *Pro Roy Soc Edinburg*, vol V, pp 575-578
44. EUDES-DESLONGCHAMPS, J A 1866 Remarques sur les os intermaxillaires chez l'homme, *Bull Soc Linn de Normandie*, T X
45. LARCHER, J F 1868 Contribution à l'histoire de la rhinocephalie et des os intermaxillaires dans l'espèce humaine, *Jour d Anat et de Physiol*, T V, pp 167-177
46. HAMY, E T 1868 Les os intermaxillaires de l'homme à l'état normal et pathologique, Paris Thesis, N 250, pp 1-86
47. CALLENDER, G W 1869 The formation and early growth of the bones of the human face, *Philos Trans*, pp 163-172
48. BROCA, P 1869 L'Ordre des Primates *Bull Soc d Anthropol Paris*, T 4, pp 288-401
49. SAPPÉY, PH C 1876 Traité d'Anatomie Descriptive, T 1, pp 214-218, *Paris*
50. TOPINARD, P 1878 Anthropology, pp 39-40, *London*
51. HOLDEN, L 1878 Human Osteology, Fifth edition, pp 97-98, *London*
52. ALBRECHT, P 1882 Sur les quatre os intermaxillaires, *Bull Soc d Anthropol de Bruxelles*, pp 73-95
53. KOLLIKER, I H 1882 Über das Os intermaxillare des Menschen, etc, *Nova Acta der Leopold Carol Akad der Naturforscher*, Halle, Bd XLIII, pp 327-395
54. ALLEN, H 1882 A System of Human Anatomy, pp 134-135, *Philadelphia*
55. TURNER, W 1884 The relation of the alveolar form of cleft palate to the incisor teeth and the intermaxillary bones, *Jour Anat & Physiol*, vol 19, pp 198-213
56. BLAND SUTTON, J 1884 Observations on the parasphenoid, the vomer, and the palatopterygoid arcade, *Proc Zool Soc Lond*, pp 566-573
57. TOPINARD, P 1885 Éléments d'Anthropologie Générale, *Paris*, p 60
58. BROCA, P 1887 *Bull Soc Anatomique, Paris*
59. BERARD 1888 Les os intermaxillaires, Thèse de médecine de Montpellier
60. KOLLIKER, T H 1888 Über Zwischenkiefer, *Anat Anz*, Bd 3, pp 577-579
61. BIONDI 1888 Über Zwischenkiefer, *Anat Anz*, Bd 3, pp 577-579
62. GILIB, E 1888 *Bull de la Soc Anatomique*, Sr 5, T II, pp 372-374
63. ALLEN, H 1890 On hyperostosis of the premaxillary portion of the nasal septum, *Med News, Philadelphia*, vol 57, pp 183-186
64. OSBORN, H F 1892 Present problems in evolution and heredity, The Cartwright Lectures, Lect 1, *The Med Record*, vol 41, p 200
65. FORBES, H O 1894 Monkeys, vol 1, p 221, *London*
66. SUSDORF, M 1895 Lehrbuch der vergleichenden Anatomie, Bd 1, pp 210-213, *Jena*
67. TESTUT, L 1899 Traité d'Anatomie Humaine, T 1, pp 198-199, *Paris*
68. FRISON, M L 1901 De la nécrose des os intermaxillaires, Paris Thesis, pp 1-120
69. RANKE, J 1901 Über den Zwischenkiefer, *Corr Blatt Anthropol Ethnol u Urgesch*, No 9, pp 96-102
70. RABL, C 1902 Die Entwicklungsgeschichte des Gesichtes, *Leipzig*
71. JEFFERY, L 1904 A case of absence of the intermaxillaries, *Brit Dent Jour*, vol 25, N S, pp 501-502
72. FISCHER, A 1905 Ueber einen menschlichen Schädel ohne Zwischenkiefer, *Anat Anz*, Bd XXVII, No 24, pp 561-575
73. LE DOUBLÉ, A F 1906 Traité des Variations des Os de la Face de l'Homme, *Paris*, pp 244-261
74. ANDERSON, R S 1908 Some notes on the hard palate and maxilla in primates, *Brit Med Jour*, vol 2, p 596
75. PREISWERK, P 1908 Die Rolle des Zwischenkiefers bei der Bildung von Zähnen und Kieferanomalien, *Deutsche Monatsf Zahnheilk*
76. MOSHER, H P 1909 The influence of the premaxillae upon the form of the hard palate and upon the septum, *Items of Interest*, N Y, vol XXXI, pp 481-515
77. HOFF, L 1909 The Human Species, p 59, *London*
78. FAWCETT, E 1911 The development of the human maxilla, vomer and parasphenoid cartilage, *J Anat Physiol*, vol 45, pp 378-406
79. BRUNI, A C 1911/12 Studio sullo sviluppo della regione intermaxillare nell'uomo, *Atti della R Acad Sci di Torino*, vol 47, pp 154-156
80. FRETZ, G P 1912 Beiträge zur vergleichenden Anatomie und Ontogenie der Nase der Primaten, *Morph Jahrb*, Bd 44, pp 409-461
81. INOUE, M 1912 Der Zwischenkiefer, usw, *Anat Hefte*, Bd 45, pp 475-610

82. BOLK, L. 1913. Über die Obliteration der Nähte am Affenschädel, u.s.w., *Zeits. f. Morph. u. Anthropol.*, Bd. 15, pp. 1-206.
83. WALKER, C. 1917. Absence of the pre-maxilla, *J. Anat. Physiol.*, Vol. 51, pp. 392-399.
84. RICHARDSON, C. W. 1918. Report of syphilitic necrosis of the intermaxillary portion of the superior maxilla, *Laryngoscope*, vol. 28, p. 907.
85. WOOD JONES, F. 1918. The Problem of Man's Ancestry, p. 36, *London*.
86. FELBER, P. 1919. Anlage und Entwicklung des Maxillare und Praemaxillare beim Menschen, *Morph. Jahrb.*, Bd. 50, pp. 451-499.
87. JARMER, K. 1922. Über die mehrfache Anlage des Zwischenkiefer beim Menschen. *Zeits. f. Anat. u. Entwickl.*, Bd. 64, pp. 56-76.
88. HERBST, E. 1923. Die Bedeutung des Zwischenkiefers für die Missbildungen des menschlichen Gebisses, *Deutsche Monat. f. Zahnheilk.*, Jhg. 41, pp. 481-509.
89. BERCHER, J., AND MERVILLE. 1923. Deux cas de syphilis tertiaire de la région incisive supérieure, *Rev. de Stomatologie*, vol. 25, pp. 198-204.
90. ———. 1923. Deux nouveaux cas de nécrose de l'os intermaxillaire chez des hérédosspécifiques, *Rev. de Stomatologie*, vol. 25, pp. 414-417.
91. BERCHER, J. 1924. Cause occasionnelle de la nécrose syphilitique de l'os intermaxillaire, *Paris Med.*, vol. 53, pp. 190-191.
92. VALLOIS, H. V., AND CADENAT, E. 1924. Développement de l'os prémaxillaire chez l'homme, *C.-R. Soc. Biol. Paris*, vol. 90, pp. 1322-1324.
93. WOOD JONES, F. 1925. The Ancestry of Man, *Brisbane*.
94. ZITTEL, K. A. 1925. Text Book of Palaeontology, vol. 3, p. 383, *London*.
95. SINGER, C. 1925. From Magic to Science, p. 61, *London*.
96. REMANE, A. 1927. Der Verschluss der Intermaxillar-naht bei den Anthropoiden, *Anthropol. Anz.*, Bd. 4, pp. 46-55.
97. MURAKAMI, K. 1928. Die knöchernen Gaumen der Japaner. *Arbeit. Anat. Inst. Univ. zu Sendai*, Heft 13, pp. 1-77.
98. MIJSBERG, W. A. 1928. Die Obliteration der Nähte des Gesichtsschädels der Javenern, *Zeits. f. Morph. u. Anthropol.*, Bd. 27, pp. 199-244.
99. MARTIN, R. 1928. Lehrbuch der Anthropologie, *Jena*.
100. WOOD JONES, F. 1929. Man's Place Among the Mammals, pp. 316-319, *London*.
101. SCAMMON, R. E., AND CALKINS, L. A. 1929. The Development and Growth of the External Dimensions of the Human Body in the Fetal Period, pp. 47-49, *Minneapolis*.
102. WALTER, H. E. 1929. Biology of the Vertebrates, p. 541, *New York*.
103. EHRLHARDT, G. 1930. Über das Verwachsen der Sutura incisiva bei Orang-utan und *Hylobates*, *Anthropol. Anz.*, Bd. 7, pp. 106-116.
104. HERBST, E., AND APFFELSTADT, M. 1930. Malformations of the Jaws and Teeth, pp. 118ff., *Oxford*.
105. KROGMAN, W. M. 1930. Studies in growth changes in the skull and face of anthropoids, *Am. J. Anat.*, vol. 46, pp. 315-353.
106. PIERCE, G. A. 1930. Human Anatomy, pp. 202-203, *New York*.
107. FRAZER, J. G. 1931. A Manual of Embryology, p. 280 & p. 295, *London*.
108. CUNNINGHAM, D. G. 1931. A Text Book of Anatomy, p. 142, & p. 209, *London*.
109. AERY, L. B. 1932. Developmental Anatomy, p. 414, *Philadelphia*.
110. AUGIER, M. 1932. Sur le développement du prémaxillaire humain, *C.-R. l'assoc. anatom.*, 27 réunion, pp. 18-28.
111. LIMSON, M. 1932. Observations on the bones of the skull in white and negro fetuses and infants, *Contributions to Embryology*, No. 136, pp. 205-22.
112. KEITH, A. 1933. Human Embryology and Morphology, p. 144, *London*.
113. MORRIS-JACKSON. 1933. Human Anatomy, pp. 168-169, *Philadelphia*.
114. FRAZER, J. G. 1933. The Anatomy of the Human Skeleton, *London*.
115. FRANZ, V. 1933. Goethes Zwischenkieferspublikation nach Anlass, Inhalt, und Wirkung. *Ergeb. Anat. u. Entwickl.*, Bd. 30, pp. 469-550.
116. BOYD, J. D. 1933. The classification of the upper lip in mammals, *J. Anat.*, vol. 67, pp. 409-416.
117. SCHULTZ, A. H. 1932. The hereditary tendency to eliminate the upper lateral incisors, *Human Biology*, vol. 4, pp. 34-40.
118. SCHULTZ, A. H. 1934. Inherited reductions in the dentition of man, *Human Biology*, vol. 6, pp. 627-631.



NEW BIOLOGICAL BOOKS

The aim of this department is to give the reader brief indications of the character, the content, and the value of new books in the various fields of Biology. In addition there will frequently appear one longer critical review of a book of special significance. Authors and publishers of biological books should bear in mind that THE QUARTERLY REVIEW OF BIOLOGY can notice in this department only such books as come to the office of the editor. The absence of a book, therefore, from the following and subsequent lists only means that we have not received it. All material for notice in this department should be addressed to Dr. Raymond Pearl, Editor of THE QUARTERLY REVIEW OF BIOLOGY, 1901 East Madison Street, Baltimore, Maryland, U. S. A.

EXPERIMENTAL EVOLUTION

Being a review of *The Struggle for Existence*
by G. F. Gause. Baltimore (The Williams & Wilkins Co.), 1934. Pp. ix + 163. 9 x 6 inches. \$3.00.

By Thomas Park, Department of Biology,
School of Hygiene and Public Health,
The Johns Hopkins University.

Much has been said about the struggle for existence and its rôle in evolution, in fact, Charles Darwin wrote a book on the subject in 1859. However, up until the last fifteen years little of real advance has been contributed towards the problem since Darwin's writings. These pertinent facts are pointed out in the foreword to Gause's book by Raymond Pearl, pioneer of the modern population school, who says

At the present time there is abundant evidence of an altered attitude, and particularly among the younger generation of biologists. The problem (i.e., the struggle for existence) is being attacked, frontally, vigorously and intelligently. This renewed and effective activity seems to be due primarily to two things: first, the recrudescence of general interest in the problems of population, with the accompanying recognition that population problems are basically biological problems, and, second, the realization that the struggle for existence and natural selection are matters concerning the *dynamics of populations*, birth rates, death rates, interaction of mixed populations, etc.

As can be seen from the foregoing, Doctor Gause studies the struggle for existence by combining the technique of the experimental population student with that of the mathematician and statistician. The book is organized around six chapters. Chapter I, "The problem", Chapter II, "The struggle for existence in natural

conditions", Chapter III, "The struggle for existence from the point of view of the mathematicians", Chapter IV, "On the mechanism of competition in yeast cells", Chapter V, "Competition for common food in protozoa," and Chapter VI, "The destruction of one species by another."

In Chapter I the author outlines the problem and its attack as he sees it. Simply put, the procedure consists in setting up and reviewing experiments with relatively simple organisms which are in some form of competition or "struggle" either with themselves, their food supply, or with other species occupying a similar ecological niche. To these actual experimental data are applied certain mathematical constants, to be mentioned later, which tend to place the results on a comparable basis relative to competition and to give a quantitative expression of the intensity of the struggle for existence. Yeast cells and various species of protozoa are the organisms from which the deductions are drawn. The author's opinion as to the relative value of mathematics and biology in attacking this problem can best be stated in his own words:

There is no doubt that the struggle for existence is a biological problem, and that it ought to be solved by experimentation and not at the desk of a mathematician. But in order to penetrate deeper into the nature of these phenomena we must combine the experimental method with the mathematical theory, a possibility which has been created by the brilliant researches of Lotka and Volterra. This combination of the experimental method with the quantitative theory is in general one of the most powerful tools in the hands of contemporary science.

In the second chapter, Doctor Gause reviews some of the features of the struggle

for existence as it has been observed in nature. It is pointed out, and pertinently so, that plant and animal communities, although frequently possessing a definite ecological structure, are typically too complex in their structure and function to permit of many simple deductions relative to competition. It is possible, however, to get a not-too-complex conception of the struggle for existence in nature by witnessing competition, both interspecific and intraspecific, between certain organisms of relatively simple plant and animal communities. In summarizing this phase of the problem Gause says:

... let us note the following picture of the struggle for existence in nature. It is only in the domain of botany that these processes are coming to be investigated from a certain general viewpoint as (1) intensity of competition, (2) competition in mixed populations, (3) the influence of environment upon competition in mixed cultures, and (4) the rôle of the quantitative relations between species at the beginning of their struggle. Among animals the processes of the struggle for existence are much more complex, and as yet one cannot speak of any general principles. In this connection an investigation of the elementary processes of the struggle for existence in strictly controlled laboratory conditions is here particularly desirable

In the third chapter the struggle for existence is discussed from the mathematical viewpoint. Here the author's material shows the influence of the work of Pearl, Lotka and Volterra. Gause discusses the calculation and significance of two types of mathematical constants: the coefficients of multiplication, b_1 and b_2 , and the coefficients for the struggle for existence α and β . These constants are used in developing differential equations describing the struggle for life; equations which start out as comparatively simple expressions dealing with an idealized situation but which soon add complication upon complication to meet the demands of the increasing complexity associated with the struggle for existence. Gause is quite aware as to the futility of applying mathematical methods of description to complex cases of competition. This leads him to deal entirely with experimental yeast and protozoan populations in which he feels the mathematical technique is justified.

In the last three chapters of the book

Doctor Gause discusses respectively the growth of yeast populations and the competition existing in such populations between the yeast cells; the competition for common food exhibited by growing cultures of protozoa (*Paramecium* sps., *Stylonychia*), and the predator-prey type of struggle for existence exemplified by *Didinium*, the predator, and *Paramecium*, the prey. It would be pointless to discuss here many of the author's findings on these matters. Suffice it to say that, in not-a-few instances, the theoretical equations describing the various phases of the struggle for existence are completely substantiated by the actual experimental data. This seems to hold especially true for the simpler conditions of experiment.

Of particular interest, however, and worthy of more detailed treatment, is Gause's discussion of the predator-prey type of population interaction. The mathematicians, Lotka and Volterra, have developed equations which describe the struggle for existence when two species, one a predator, the other the prey, inhabit the same microcosm. These equations lead to the prediction that the numbers of prey and predators will fluctuate in definite cycles of abundance and sparseness due to innate properties of the biological system itself not related to external environmental forces. The story, as described by the mathematicians, runs something like this: if, in a limited environment we have n_1 number of prey, and, if an n_2 number of predators are introduced into the system, the concentration of the prey diminishes and that of the predators increases. However, as the predators increase they devour more and more of the prey so that the latter become fewer in number. This creates a food shortage for the predators and most of them die off. As a result, the pressure on the prey is relieved and they increase rapidly, soon becoming the more numerous species. The few predators which did survive their food shortage now flourish and multiply abundantly and so the cycle is reconstituted. In chapter VI Doctor Gause is interested in seeing if these "classical" oscillations of predators and prey, predicted on a stochastic basis, can be realized by actual experimental data. To do this he chose two infusoria

which live under similar ecological conditions *Didinium nasutum* and *Paramecium caudatum*, the predator and the prey respectively. The former species requires for its nutriment a fresh *Paramecium* every three hours. The bacterium, *Bacillus pyocyaneus*, was always present in the medium of this and subsequent experiments to supply the *Paramecia* with food. In the first experiments five *Paramecia* were placed in a clear oatmeal medium and two days later three of the preying *Didinium* were added. After the introduction of the predators the number of *Paramecia* decrease, the *Didinium* multiply, intensely devour all the prey, and then themselves starve to death. Clearly this experiment offers no support to the predictions of the mathematicians and furnishes no evidence of an innate periodic oscillation of numbers for such a system. Gause has this interesting observation to make:

However, why is the theoretical equation of the mathematicians not realized in our case? The cause of this is apparently that a purely biological property of our predator has not been taken into account in the equation. According to this equation a decrease in the concentration of the prey diminishes the probability of their encounters with the predators, and causes a sharp decrease in the multiplication of the latter, and afterwards this even leads to their partly dying out. However, in the actual case *Didinium* in spite of the insufficiency of food continues to multiply intensely at the expense of a vast decrease in size of the individual.

This matter was tested further experimentally by slightly changing the medium in order that some of the *Paramecia* could escape from the *Didinium*. This experiment was developed on the grounds that the more heterogeneous environment simulated the natural conditions more closely. The change was brought about by using a medium containing a sediment in which the prey was free to go but which barred the predators. Under these conditions all of the *Didinium* would be found in the clear part of the medium and the *Paramecia* would be moving in and out of the sedimentary deposits. In short, the system provides the prey with a "refuge." For the majority of cases the results of this experiment were clear cut. If *Paramecia* and *Didinium* are simultaneously intro-

duced into the microcosm the latter increase somewhat and devour some of the *Paramecia*. A considerable group of the prey, however, escape into the sediment and there cannot be attacked. The *Didinium* soon eat all of the *Paramecia* in the clear part of the medium and then starve. In the meantime, the havened *Paramecia* have multiplied greatly and soon the culture becomes entirely composed of this species. Here again, under presumably more "natural" conditions, the "classical" results do not obtain.

In his third group of experiments Doctor Gause uses the clear oatmeal medium and at the beginning and every third day thereafter added one *Paramecium* and one *Didinium* to the culture. Under these conditions an actual experimental oscillation of the predators and prey was demonstrable with first the *Paramecia* being most numerous and then the *Didinium*. The author's final word on this matter is,

The above given example shows that in *Paramecium* and *Didinium* the periodic oscillations in the numbers of the predators and of the prey are not a property of the predator-prey interaction itself, as the mathematicians suspected, but apparently occur as a result of constant interferences from without in the development of this interaction. There is evidence for believing that this is characteristic for more than one special case.

This is a splendid book deserving of welcome by the ecologist, the population student, the physiologist, the student of evolution, and the theoretical biologist. It attacks a fundamental problem, uses skillful weapons and methods in its attack, and arrives at some interesting and frequently provocative conclusions. Despite the author's gifts in the mathematical field he seems admirably wary of extending his calculations beyond the confines of his experimentation; this is one of the book's chief attributes. Many of the experiments reported are original and good use is made of the bibliography on yeast and protozoa population problems. An appendix, detailing the technique of making the mathematical calculations, is also useful. The book is not, on the whole, an easy one to read; this is partly due to the complex nature

of the problem and the technical manner in which the material is treated. In the reviewer's opinion a final chapter presenting the author's matured conclusions and generalizations on the subject would have been helpful to the reader. The volume would have been better technically had the graphs, figures, and lettering been more meticulously prepared. Two mistakes in usage of proper names were

noticed in the text: "Calclins" for "Calkins" and "Nikolson" for "Nicholson."

The book ends on a note of pessimism and so may this review by quoting the last paragraph:

It is to be hoped that further experimental researches will enable us to penetrate deeper into the nature of the processes of the struggle for existence. But in this direction many and varied difficulties will undoubtedly be encountered.

BRIEF NOTICES

EVOLUTION

STUDIES OF THE PLEISTOCENE PALAEOBOTANY OF CALIFORNIA. *Contributions to Palaeontology. Carnegie Institution of Washington Publication No. 415.*

Carnegie Institution of Washington, D. C.
\$3.00 (paper); \$3.50 (cloth). 10 x 6 $\frac{3}{4}$;
179 + 31 plates; 1934.

Four papers are contained in this volume: A Pleistocene Flora from Santa Cruz Island, California, by Ralph W. Chaney and H. L. Mason; A Pleistocene Flora from San Bruno, San Mateo County, California, by Susan S. Potbury; A Pleistocene Flora from the Asphalt Deposits at Carpinteria, California, by R. W. Chaney and Herbert L. Mason; Pleistocene Flora of the Tomales Formation, by Herbert L. Mason.

Although something has been known of the geology of the Island of Santa Cruz since 1890, fossils have been noted only recently. Their occurrence in Pleistocene alluvial deposits is important in determining early distributions of modern trees. All nine of the species described in this paper are still living in California.

The second paper describes several shrubs and herbs not previously recognized as fossil in North America. All the species are living in California but not all in the immediate neighborhood. There are indications that the climate of the region described has been gradually becoming drier since Pleistocene times. There are marine deposits under the plant-bearing beds at San Bruno.

The first fossils in the Carpinteria deposit were discovered in 1927 although asphalt had been mined here for a long time before. This paper describes 25

species, nearly one fourth of them being herbs, which are usually rare in fossil deposits. Various animal remains associated with the above mentioned plants have been helpful in determining the age of the deposits and the general ecology of the Pleistocene.

The last paper is concerned with the plant fossils in the area where the earthquake of 1906 took place. The geology and the fauna of the region have been studied previously but the flora had been neglected. There is an interesting although brief account of how the fossil remains are prepared and identified. The importance of ecological relationships is stressed.



THE GREAT DESIGN. *Order and Progress in Nature.*

By various authors. Edited by Frances Mason. The Macmillan Co., New York.

\$2.50. 7 $\frac{1}{4}$ x 5 $\frac{3}{8}$; 324; 1934.

The essays in this volume were written in reply to a question, "Is there a Living Intelligence behind Nature, or does the great Cosmos somehow run itself, driven by blind force?" or as J. Arthur Thomson, one of the contributors, paraphrased it, "Is the scientifically disclosed world of order and intelligence one in which the religious mind can breathe freely?" A group of eminent scientific men wrote answers characterized by a degree of shrewd evasiveness that is not likely to add luster to their reputations. Several of them wrote popular scientific articles, expounding in scholarly fashion the provisional and speculative nature of our

knowledge of the fundamental concepts of matter, energy, and life, and the only way by which their sympathy with the religious point of view is displayed is by the inclusion of some such sentence as, "For, as St. Paul truly said, one star differeth from another star in glory," put in as though by afterthought, or by tacking on a paragraph or two at the end in quite a different literary style. Gager (p. 184) expressed a general attitude when he wrote, "I have not set out to attempt a definite answer to the question of whether there is 'mind-back-of-it-all,' but only to set forth the kind of facts and certain considerations which must be weighed if one wishes to face the question with his reason as well as with his emotions. There is no other justification in putting the question up to science at all." Only a few contributors really come to grips with the questions put to them, Lodge, Younghusband, and Fraser-Harris among them, and occasionally they reason as cogently as Paley. The consensus of opinion of this group of uncertain amateur theologians is that no one is bound to accept an answer to this question that is displeasing to him.



MEN OF THE DAWN. *The Story of Man's Evolution to the End of the Old Stone Age.* *The Thinker's Library* No. 45.

By Dorothy Davison. *Watts and Company, London.* 1 shilling net. 4 x 6½; xii + 195; 1934.

This excellent little book deals with the evolution of the primates up to man and the skeletal remains and culture of paleolithic man. Especial attention is given to the art of the old stone age and the recent discoveries in Africa. There is a bibliography of two pages and an index.



GENETICS

DIE KINDER MÄNNLICHER UND WEIBLICHER MORPHINISTEN. (*Frage der Keim- und Fruchtschädigung, Erbgang der Psychopathie*).

By Kurt Poblisch. *Georg Thieme, Leipzig.* 5.80 marks. 10 x 6½; 82; 1934 (paper).

The author has analyzed genetically 1929 adult morphine addicts—1348 male and 581 female—and examined for mental and physical defects the children produced before or after the period of addiction, and those produced during this period. The comparison between the two groups of children showed no significant differences. There was a rather high percentage of defectives in both groups, but when parents and other relations were analyzed, similar high percentages were obtained. Furthermore, the descendants of four addicts were traced with similar results. These observations indicate that the defects in the children were not due to the use of morphine by the parents.

Observations on 62 addicted mothers as to course of pregnancy and confinement showed that there was an increase in fetal movements when the usual dose was decreased or delayed; premature births were frequent; abstinence symptoms appeared in the infants shortly after birth, especially when they were deprived of mothers' milk from which they apparently received an amount of morphine; and the infant mortality rate was high. During the first month development was retarded, but thereafter progressed normally.



BREEDING AND IMPROVEMENT OF FARM ANIMALS. *Second Edition.*

By Victor A. Rice. *McGraw-Hill Book Co., New York.* \$4.00. 9 x 5½; xiii + 516; 1934.

A text-book is, in the nature of the case, bound to be a compilation of the work of many authors and a certain amount of direct quotation is illuminating and interesting. But when the work quoted is current and not difficult of access, it does seem unnecessary to carry the quoting habit to quite the extreme that Rice does.

The first edition was reviewed in Volume 2, Number 3, of *THE QUARTERLY REVIEW OF BIOLOGY*. The chapter headings of the present edition are the same as in the earlier one but considerable new material has been added—154 pages in fact. The various sections dealing with genetics have been expanded (some problems from Sinnott and Dunn's genetic text

are included for one thing) but the largest proportion of added material concerns the selection of animals for breeding. There is quite a bit of discussion of various plans proposed for breeding better producing animals.

Since this book covers such a wide field—genetics, physiology, biometry, and the "art of breeding"—it must of necessity be elementary and dogmatic in spots. This seems especially noticeable in respect to biometry and physiology.



BEEF PRODUCTION AND QUALITY AS INFLUENCED BY CROSSING BRAHMAN WITH HEREFORD AND SHORTHORN CATTLE. U. S. Department of Agriculture Technical Bulletin No. 417.

By W. H. Black, A. T. Semple, and J. L. Lush. U. S. Government Printing Office, Washington. 10 cents. 9 x 5½; 54; 1934 (paper).

A series of experiments ranging from one to three years in duration designed to compare crossbred Brahman-Hereford and Brahman-Shorthorn steers with straight Hereford and Shorthorn steers with respect to feeding habits, market desirability, size and weight, and economic value of meat produced. No very significant differences came out of the experiments, but the general feeling of the investigators was that the variations between the breeds indicated that beef cattle could be improved in feed-lot efficiency and quality of meat if more breeding experiments were carried out.



HEREDITY AND DISEASE.

By Otto L. Mohr. W. W. Norton and Co., New York. \$3.50. 8½ x 5½; 253; 1934.

A concise exposition of the history and principles of genetics written especially for medical students and physicians. It well fulfills its aim; being clear and interesting, and above all praiseworthy for the sober and rational manner in which the author considers the problems of human heredity.

NATÜRLICHE ZUCHTWAHL. *Volk und Wissen*, Bd. 15.

By Hans Stubbe. Brahm Verlag, Berlin. 90 Pfennig. 8½ x 5½; 29; no date (paper). The fundamentals of genetics are discussed with the aim of justifying the eugenic and sterilization program of the Third Reich.



DER ERBARZT. I. Jahrg., Heft 1.

Edited by O. Freiberr von Verschuer. S. Hirzel, Leipzig. 2.80 marks for 3 numbers (6 numbers appear per year); 1 mark, single copy. 11½ x 8½; 32; 1934.



GENERAL BIOLOGY

TRAITÉ DE CLIMATOLOGIE *Biologique et Médicale.* Vols. I, II, III.

Published under the direction of M. Piéry; assistant editors M. Milhaud and R. Van der Elst. Masson et Cie, Paris. 300 francs per set. 10 x 6½; xlix + 2664; 1934 (paper).

These massive volumes, prepared by the cooperative effort of some 140 collaborators working under the general editorial direction of Professor Piéry, constitute a reference work on the biological effects of climate that no biological, medical, or hygienic library can afford to be without. In fact it is unique and invaluable.

The subject matter is ordered in nine books. The first (including about 250 pages) deals with the physics and chemistry of climatology. The second discusses general climatography, for Europe in particular and the globe in general. Bioclimatology (phyto- and zoo-) occupies Book III, while Book IV is devoted to the general principles of human climatology. Book V discusses in some 400 pages physioclimatology, general and special; while Book VI deals with general and special climatopathology. The last three main divisions of the treatise are of specially medical interest, dealing respectively with the techniques and methods of climatic "cures"; medical climatography; and clinical climatotherapy.

The book is abundantly illustrated, thoroughly documented bibliographically, and extremely well edited and printed. It

ends with an index covering 52 pages, double column, set in 8-point type. In short it is a treasure that has our unre-served recommendation.



HALF MILE DOWN.

By William Beebe. *Harcourt, Brace and Co., New York.* \$5.00. $9\frac{1}{4} \times 6$; xix + 344 + 44 plates; 1934.

The title of Dr. Beebe's book *Half Mile Down* indicates the record which he established while making dives in the bathysphere. He begins with an historical account of man's devices to submerge himself, tells of his own experiences diving with a helmet and then devotes himself to describing the bathysphere dives from all points of view. His account of the actual technique used is interesting, but becomes wearisome as he repeats it upon every occasion on which the bathysphere goes down. The gradual reduction in the number of colors of the spectrum as one descends, and the reaction of the fish to his beam of light are discussed. Some fish are attracted by it, some are frightened and others are completely indifferent. The latter reaction he concludes is due to the complete absence of change in the quality of darkness at great depths.

The book is popularly written and the appendix contains detailed notes on two dives, a classified résumé of organisms observed and technical information on the bathysphere and its operation. There is a good index.

Our chief criticism of the text is that it is unnecessarily verbose.



EXPLORING WITH THE MICROSCOPE.

By Raymond F. Yates. *D. Appleton-Century Co., New York.* \$2.00. $7\frac{3}{8} \times 5$; xv + 182 + 15 plates; 1934.

Addressed to amateurs, this fascinating book tells what to look at under the microscope and how to do it. Along with the "how to do it," directions are given for making certain simple adjuncts to add to one's equipment, such as a microtome and a polariscope. It really serves as a

laboratory guide to those whose laboratory is the kitchen table.

The author accomplishes very successfully the difficult task of making a technical subject simple without talking down to his audience and without using a bed-time story style. The book does not aim to teach biology but it would be surprising if it did not stimulate many of its readers to study the subject further.



CONFESSIONS OF A SCIENTIST.

By Raymond L. Ditmars. *The Macmillan Co., New York.* \$3.50. $8\frac{1}{2} \times 5\frac{3}{4}$; xii + 241 + 4 plates; 1934.

If you are a biologist, interested in what animals really are like, or if you are a mystery story writer in search of a plot, or if you are merely a reader who likes a vivid, well-told tale,—this is a book well worth your time.

Ditmars' discovery that the vampire bat laps up blood instead of sucking it, is here retold in some detail as is his subsequent discovery that the observations had been made before. How the author felt when he lectured before the National Geographic Society at Washington and how he served his apprenticeship on a newspaper are some of the less scientific but not less interesting confessions.



BIOLOGISCHER WILLE. *Wege und Ziele biologischer Arbeit im neuen Reich.*

By Ernst Lehmann. *J. F. Lehmann, München.* 2.50 marks. $7\frac{1}{2} \times 4\frac{7}{8}$; 113; 1934 (paper).

Lehmann, the Director of the Botanical Institute at Tübingen, believes that, as in the nineteenth century idealistic philosophy became the unifying character underlying the German universities, so at the present time biological thought is becoming the pervading element. In this book he traces the trends of biological teaching not only in the schools, but also in the cultural, scientific and even political life of the German people. He offers suggestions for the course of study from the primary schools on up through the universities, and lists numerous vocations

in which a thorough biological training would be of great benefit.



TRAVAUX DU LABORATOIRE DE MICROBIOLOGIE DE LA FACULTÉ DE PHARMACIE DE NANCY. Fasc. VII.

50 francs. 9½ x 6½; 234 + 15 plates; 1934 (paper).



HUMAN BIOLOGY

CHAN KOM. *A Maya Village*. Carnegie Institution of Washington Publication No. 448.

By Robert Redfield and Alfonso Villa R. Carnegie Institution of Washington, D. C. \$4.25 (paper); \$5.25 (cloth). 12 x 9; viii + 387 + 16 plates; 1934.

This is a detailed monographic account of the life of a peasant village, Chan Kom, in Yucatan. This village has a total population of 251 (131♂ and 120♀) of which 48.6 percent are under 15 years of age, and only 4.8 percent 50 or more years old. Natality and mortality are both high. Contraception is apparently unknown. The people are racially homogeneous in high degree, conforming to the Maya Indian type. Whatever admixture of white blood there may have been in the past, it must have been small. Since Chan Kom is situated in a zone between the henequen and the chicle areas, the people work only for themselves. They raise corn which they either consume or sell or barter for manufactured goods; and for the rest they hunt, keep bees, poultry and hogs, and to some extent other livestock. There is little of either wealth or inequality in its distribution, but still individual differences in ability do make themselves apparent in worldly goods. There is a good deal of communal labor and effort generally. *Fagina* is the name for the labor that every man in the village has to give, without compensation, for the public good.

The performance of *fagina* is attended with the impressiveness of collective determination and the

stimulus of a situation where all men work shoulder to shoulder on one common task. When *fagina* has been decided upon, all the men meet at the *cuartel*, and first taking note of any absentees, that derelictions may not go unpunished, they go off together, with their tools, to the place where the task is to be done. At the meeting the night before when *fagina* was decided upon, there have been speeches exhorting the people to special effort that Chan Kom may grow in power and prestige, these words are still in the ears as they go out to do the work, and perhaps the *comisario*, who is with them as their leader, urges them on with fresh exhortations. During the work there is plenty of opportunity to talk and to joke; *fagina* is permeated by a cheerful enthusiasm.

In sum, it is a primitive people living in a primitive state of culture that this volume describes. The description is minutely detailed, and covers practically every aspect of life. Indeed the most important criticism of the book is that no attempt is made at any point towards a general synthesis of the results into a unified picture. The intertwined threads of fact are left in a tangled skein. Nor is there much offered in the way of comparison with other peoples and cultures. And surely ethnology and sociology are comparative sciences. A description of a particular people or a particular culture, however meticulous, has little meaning except as it serves to establish relationships to others. To be sure the authors specifically state that this volume is but the first in what is hoped to be a comparative study of Mayan cultures. But even so it would seem to have been possible, and profitable, to have been even at this stage a little less detached.

Two very interesting and valuable features of the book are (a) an autobiography contributed by Eustaquio Ceme, the only man in the village sufficiently literate to write such a document. He is one of the three *principales* of Chan Kom, and its outstanding civic leader. He is a successful man and proud of it. The other document is (b) the diary kept by the junior author, who is the village school master, from February 16, 1930 to November 21, 1931.

The volume closes with a glossary of plant and animal names, a short bibliography, and a detailed index. As a contribution of factual material for future synthesis and comparative research it stands in the first rank.

JÖNS JACOB BERZELIUS. *Autobiographical Notes.*

Published by The Royal Swedish Academy of Sciences through H. G. Söderbaum.

Translated from the Swedish by Olof Larsell. The Williams & Wilkins Co., Baltimore.

\$2.50. 8 x 5½; xi + 194 + 3 plates; 1934.

Of this autobiography of Berzelius, written in fulfillment of a requirement of the Swedish Academy of Sciences, three manuscripts are extant. In his school and college years his interest in natural history and chemistry, which led him to neglect some of his other studies, did not meet with the sympathy of some of his teachers. For a number of years after his graduation in medicine he found it difficult to make ends meet. His attempts to supplement his meager stipend by lectures on chemistry brought in little money, but in time his chemical researches gained him fame and a comfortable income. There are interesting accounts of Davy, Young, Goethe and others whom Berzelius met in his travels. Davy had married a rich widow and was growing more interested in shining as a man of fashion than as a chemist. Berzelius had annotated his copy of Davy's *Elements of Chemical Philosophy*, which had just been published, with criticisms of some of the author's statements. Later he visited Young at his country estate at Worthing.

When I came down quite early on the following morning into the living room I found Young occupied with entering into his own copy of the book by Davy the marked places in mine. At my question as to why he did this he answered quite frankly that he desired to talk with me about the items which were marked. He had undertaken to review the book for a literary journal and believed that a thorough criticism of it would be nothing more than justice to the author, who had been made arrogant by success. I declared then that in such a case he should receive no explanation of the notations which had been made. I represented to him that such a criticism could possibly awaken in Davy a distaste for science, since he had already given reasons to fear that he intended henceforth to occupy himself less than formerly with chemical investigations. Further I reminded him of Chevenix, who, because of the criticism he had received in scientific circles as a result of an attempt to produce palladium artificially, had permanently given up his work in chemistry, as he himself had assured me a few days previously. Young admitted the correctness of these remarks and added that Davy was even more sensitive than Chevenix. The following morning he read me his review in which, with just but perhaps somewhat too far-driven praise, he set

forth the new views laid down by Davy in the book. He then requested explanations of my notations at the marked places, to be subjects only for his own information. I gave them to him in confidence, but when Davy returned, some time after my homeward journey, Young sought him in order to win his closer friendship by bringing my notations to his knowledge. Through this a feeling of hostility against me was awakened in Davy, which indeed became milder in time but never was fully dispelled.

The book also contains parallel passages from the other two manuscripts and explanatory notes by the editor. It is illustrated with a portrait of Berzelius, a photograph of his birthplace, and a facsimile of a page of his manuscript. There is no index.



RACES, NATIONS AND JEWS.

By Joseph Tenenbaum. Bloch Publishing Co., New York. \$2.00. 7½ x 5½; x + 170; 1934.

The author of this book, a Jewish leader in Eastern Europe who served as medical officer in the Austro-Hungarian army for four years, came in 1920 to New York. While still practising surgery he devoted much time to the study of the social and economic problems of the Jewish people. In this book he first discusses what factors and conditions go into the development and maintenance of races and nationalities. If the Jews are to be considered as a race there can be no Jewish race purity because of the blending which has taken place from the time the Hebrew nomads first drifted into Palestine about 1400 B.C. on down through the centuries wherever their descendants made their homes. The "Semitic nose" was acquired through intermarriage with the Canaanites. Today the Jews "of various countries differ among themselves more than they do from the Gentile populations of the same countries." Concerning the nationality of Jews (and other peoples as well) he believes that the "only criterion that can be relied upon to identify the true background of nationality is the fact of being national-conscious." . . . "To deny the existence of a Jewish nationality is to deny the very meaning of nationality."

The latter part of the volume is concerned with nationalism, supernationalism

and anti-semitism; statistics, statics, and dynamics; and socio-economic problems of the Jews in America. Among the numbers of Jews in the different countries of the world we find that the United States has the greatest number, something over 4,000,000 (3.5 percent of the total population); Poland 3,000,000 (10.4 percent of the total population); England and Ireland 320,000 (0.7 percent of the total population), and Canada 170,000 (1.4 per cent of the total population).

In the final chapter a plea is made for "the cohesive power of national consciousness embracing world Jewry as one indivisible unit. *It is to the best interests of the nations and humanity in general that there shall be a free, national-conscious and united Jewish people.*"

The volume is without index.



DYNAMICS OF POPULATION. *Social and Biological Significance of Changing Birth Rates in the United States.*

By Frank Lorimer and Frederick Osborn.
The Macmillan Co., New York. \$4.00.
9½ x 6½; xiii + 461; 1934.

In the opinion of the reviewer this is one of the best and most systematic studies of qualitative population trends yet to be published. It is an unprejudiced survey based on critical analysis of hundreds of factual studies recently made on population and eugenic problems. The authors, one feels, have no axe to grind, but are presenting only data that can be measured with scientific accuracy, and sifting out conclusions which are therefore all the more forceful.

The book divides into four parts. Part I, "Population Trends of American Groups," deals with fertility in relation to size of community, race, nativity, occupation and economic status; Part II, "Measurable Characteristics of American Groups," concerns variations in health, culture and intellect among different racial and regional groups; Part III, "Influences of Differential Reproduction of the Characteristics of the American People," and Part IV, "The Causes and Controls of Population Trends." In chapter 14, devoted to conclusions, the authors say

In general, it is evident that those who enjoy the greatest cultural resources are not having enough children to replace themselves in the next generation, and that the most undeveloped groups in our national life are the chief sources of population increase. Moderately high reproduction rates are found in agricultural areas with high indices of cultural-intellectual development, but the population included in such areas is certainly less than half of the total farm population of the nation. And, with the exception of a few sparsely populated states in the Rocky Mountain division, the states with conspicuously high reproduction rates are also characterized by very low ratings on indices of cultural-intellectual level.



THE SECOND-GENERATION JAPANESE PROBLEM.

By Edward K. Strong, Jr. Stanford University Press, Stanford University, Calif.
\$3.25. 8½ x 6; viii + 292; 1934.

A special study of the educational and vocational opportunities offered the second generation Japanese in California was made by the author and collaborators and published elsewhere in full detail. This book contains a summary of the results and conclusions. It is clearly evident that on the average the American born Japanese differs very little or none at all from his white contemporaries in mental or moral qualities. His physical characteristics are the apparent cause of any discrimination against him. How great is this discrimination cannot be known. It is practically always denied by the whites, nevertheless the Japanese feel that it is universal. The opportunities for the future, according to the author, depend on the degree of racial prejudice and in California, at least, do not appear very good. All indications suggest that it is best for the youngsters to follow the occupations of the fathers, who in late years have shown a tendency to leave farming in favor of small business. It is of interest to note that the chances of true assimilation with the whites are practically impossible because the Japanese frown on mesalliances. The idea of a people within a people should not be alarming when one considers that there is no more immigration. The Japanese are after all few in number and their fertility is declining.

Although the results are as expected, this investigation has been well con-

ducted and deserves to be used as a model for similar studies on other racial groups.



ENQUÊTE SUR LES CONDITIONS DE VIE DES FAMILLES NOMBREUSES EN BELGIQUE.

Analysis of the results by Aimée Racine, Preface by Ernest Mahaim, Sociological conclusions by Eugène Dupréel. Recueil Sirey, Paris. 20 francs. 9 $\frac{3}{4}$ x 6 $\frac{3}{8}$; 175 + folding plate; 1933 (paper).

It is a fact that large families are anachronistic in our present society. The Belgian Committee of the International Population Union has therefore conducted an enquiry on 140 families, each composed of 5 or more children, for the purpose of investigating their social and economic status and especially the mental attitude of the parents. The selection of the material and the form of questionnaire are not above criticism as admitted by Professor Dupréel, who draws the sociological conclusions. These show that the mother is the nucleus around which the family moves, but the moral and mental qualities of the father are those which determine the status of the family. So, there are two classes of prolific families: One, in which the father has a firm conviction of the desirability of having many children and the satisfaction of thus serving God and his country. This accompanies a higher economic and social level. The other category of families includes those beset by poverty, disease and ignorance, and fathered by weak men, each of whom has a large family because he does not know how to avoid it.

The writers, limited by their theme, have failed to make it clear that the association between the qualities of the fathers and status of the family is probably not particular to prolific families.



FIVE HUNDRED DELINQUENT WOMEN.

By Sheldon and Eleanor T. Glueck. Alfred A. Knopf, New York. \$5.00. 9 $\frac{3}{8}$ x 6 $\frac{1}{2}$; xxxiv + 539; 1934.

This is the first of a series of studies projected under the auspices of the Institute of Criminal Law of the Harvard Law

School. Roscoe Pound contributes an introduction. The book deals with a "detailed survey of the background and traits of delinquent and criminal women, of the peno-correctional treatment to which such offenders are subjected, and of the practical results of such treatment in terms of reform or recidivism." Also, there is an inquiry into the response of various classes of offenders to the different types of peno-correctional treatment actually provided by society. It is impossible to give in a brief space any conception of the highly adequate way in which this survey has been made but for thoroughness in the collection of material and in critical judgment in sifting results the work stands as a model for all those undertaking studies along similar lines. The authors stress the fact that at present too little is known about the "basic problem of the relative rôles of heredity and acquired qualities in the disposition and behavior of human beings" for adequate methods to be applied successfully to delinquents and that it is of the "utmost importance that careful biologic and sociologic research and experimentation go hand in hand with 'practical programs' designed to 'produce immediate results.'" Fully two-fifths of the volume is concerned with *Methods of this research* (Appendix A) and *Schedules and forms* (Appendix B). The foot-notes, references and detailed index add to its usefulness.



POPULATION THEORIES AND THEIR APPLICATION with Special Reference to Japan.

By E. F. Penrose. Food Research Institute, Stanford University, Calif. \$3.50. 8 $\frac{1}{2}$ x 5 $\frac{1}{2}$; xiv + 347; 1934.

The contents of this book are divided into three parts: Part I, "Theories of population"; Part II, "Some aspects of the Japanese population problem," and Part III, "The distribution of population and the distribution of natural resources." The book is economic in emphasis, stressing such problems as agriculture, industrialization, territorial expansion, and international trade. Coming at the present time, when the problems of Japan are so real to the civilized world, the

book will at least attract many and varied readers if not make friends. One of the author's important viewpoints may be put in his own words:

Some thinkers have held that war and other social conflicts arise out of blind impersonal forces inherent in nature and beyond human control. For a time it was held by many that an instinct of pugnacity belonging to man's biological inheritance made war inevitable, but this view is now discredited in scientific circles. Many population students, however, have held that the reproductive capacity of man is so far in excess of his productive capacity that the pressure of numbers on productive resources is a standing menace to world peace and to social harmony. Actually, productive capacity is the one thing which shows no sign of failing, while reproductive capacity is now being brought so rapidly under individual control that over wide areas fertility rates have fallen below replacement level.



CONSTRUCTIVE EUGENICS *and Rational Marriage.*

By Morris Siegel. McClelland and Stewart, Toronto. \$2.50. 7½ x 5½; xiii + 196 + 2 plates; 1934.

It is not possible for one to agree with all of the tenets of this book. Nevertheless the author's main contention that there should be an educational program to instruct the young to make certain discriminations in choosing mates is sound. In the olden days, the custom for marriages to be arranged by the parents had as a rule a definitely beneficial effect upon the type of offspring produced. Nowadays, when parental authority in matrimonial affairs is significantly small the author believes that the following program is promising of good results:

Compulsory teaching of eugenics in Middle and Higher Schools; More extensive instruction in heredity and eugenics for undergraduates in Medicine, Post Graduate courses in heredity and eugenics, for the training of specialists; Propaganda; Federal or Dominion Eugenic Department.

The volume is indexed. Chancellor Whidden of McMaster University of Canada contributes an introduction and Drs. J. R. Parry and Morton of Hamilton, Ontario, a foreword.



MATERNAL MORTALITY IN PHILADELPHIA 1931-1933. *Report of Committee on Maternal Welfare, Philip F. Williams, Chairman.*

Philadelphia County Medical Society, Philadelphia. \$1.00. 9 x 6; 144 + 4 folding charts; 1934 (paper).

In order to make this study comparable to that in progress in New York the line of survey and analysis which was in use by the Committee of Public Health Relations of the New York Academy of Medicine was adopted. For the three years (1931, '32, '33) there occurred in Philadelphia 717 maternal deaths to 99,579 total births. Eliminating 78 non-obstetrical causes of deaths there remained a puerperal death rate of 6.69 per thousand live births. Of the 639 deaths, 529 occurred in white women and 110 in negroes. The data concerning the causes of these deaths have been collected and analyzed with the utmost care and presented in tabular and graphic form in the report. The latter part of the study deals with recommendations and discussion. It is the intention of the Committee to continue the survey for three more years during which time the members of the Committee on Maternal Welfare and the Auxiliary Analysis Committee may have time to bring before the hospital staffs and medical societies their findings and recommendations. This admirable report might well serve as a model for similar surveys in other large centers of population in the United States.



THE DOCTOR IN HISTORY.

By Howard W. Haggard. Yale University Press, New Haven. \$3.75. 9½ x 6; xiii + 408; 1934.

This "history of health," the author tells us in the preface, was written for his children in order that they might be able to think "logically and soundly on the social matters of medicine in these years of faddism, quackery and commercially exploited 'health appeal'." He believes that the student should have a thorough knowledge of man's greatest and longest struggle from earliest times, namely, to survive against disease, as well as a knowledge of the history of man's struggle against man or against geographical barriers. Too often the study of present day hygiene consists in the glib recitation of the dicta of today "many of which will

surely become the absurdities of tomorrow." Beginning with the earliest known methods of healing; namely, magic, mystery and superstition, the author leads the reader on through the centuries, pointing out the various fashions in medicine and sifting out those methods which have proved to be of permanent value. The great contributors to medicine are arrayed beside the great quacks. The book is interestingly written and abundantly illustrated and indexed. An excellent volume for general and high school libraries.



THE CHILD. *His Origin, Development and Care.*

By Florence B. Sherbon. McGraw-Hill Book Co., New York. \$3.50. 8 x 5½; xix + 707; 1934.

This book, by the Professor of Child Care and Development in the department of home economics in the University of Kansas, was written for students who have had no special training in biology. It is an endeavor "to present the whole child, from his earliest origins until we lead him to the schoolroom door." Picking at random one finds such topics discussed as heredity, evolution of reproduction, glands of internal secretion, hygiene of pregnancy, birth of the child, hygiene of childhood, the brain, theories of behavior and learning, etc. etc. Occurring with considerable frequency throughout the text are poetic quotations which have some sentimental bearing on the subjects under discussion. One is considerably amused to read the author's advice in the preface. The student is urged to spend the first week merely reading steadily through the text. "Especially read the poetry now, and again and again. The poet is a true scientist and often gives us in a magic flash of words the gist of a weighty scientific tome." The volume is abundantly illustrated and documented and contains numerous tables and charts. In a series of appendixes are discussed basal metabolism, anaesthetics used in child birth and immunization. There is also a glossary and a detailed index. Undoubtedly a

useful volume for the purpose for which it was designed.



PATTERNS OF CULTURE.

By Ruth Benedict. Houghton Mifflin Co., Boston. \$2.50. 8½ x 5½; xiii + 291; 1934.

In this interesting book Dr. Benedict develops the thesis that the culture of a society cannot be understood by cutting it up into isolated categories, such as economic life, religion, and the like, that different cultures have different dominating ideas which integrate the approved behavior in the different departments of social activity. She has therefore chosen for analysis three contrasting primitive cultures, the Zuñi Indians of New Mexico, the Dobuans of Melanesia, and the Kwakiutl of British Columbia. The Zuñi believe in the golden mean and in self-effacement for the sake of society. In Dobu suspicion and enmity are the dominating ideas. The good man is the one who by his potent sorcery has got the best of his neighbors. The mainspring of Kwakiutl society is self-glorification. The conspicuous waste of their potlatch feasts would shame a millionaire of the Mauve Decade. It is evident that a personality that would fit in well among the Kwakiutl would be sadly out of place among the Zuñi and vice versa.

The book contains an introduction by Dr. Franz Boas, eight pages of bibliographic notes and an index.



SECRETS OF SIBERIA.

By Pierre Dominique. Translated from the French by Warre B. Wells. Hutchinson and Co., London. 10s. 6d. net. 8½ x 5½; 288; 1934.

No one with a real interest in the Soviet régime should fail to read this book which so fairly and so clearly depicts the efforts which are being made to industrialize Siberia along American lines and to "collectivise" the peasantry in order to feed the working population of the new

towns. The author, a keen observer and an interesting writer, conveys to his readers perhaps more effectively than has ever been done before just what is taking place in this colossal effort to swing large groups of peoples with centuries of background for particular types of life 'about face' within a period of a few years. That there was bound to be wastage of life and property, intense suffering and discontent must have been foreseen by the zealous Communist leaders, but did they comprehend the enormity of their task in mechanizing mankind? Again, one is compelled to urge the serious student to read of the great Asiatic experiment as presented in this book. The volume is illustrated but is without index.



THE SO-CALLED WENDS OF GERMANY AND THEIR COLONIES IN TEXAS AND IN AUSTRALIA. *The University of Texas Bulletin* No. 3417. *Bureau of Research in the Social Sciences Study* No. 7.

By George C. Engerrand. *University Publications, University of Texas, Austin*. Free. 8 $\frac{3}{4}$ x 5 $\frac{1}{2}$; 179; 1934 (paper).

From about the sixth to the tenth century the eastern part of what is now Germany was inhabited mainly by Slavic-speaking tribes. From the tenth century on these tribes were conquered by the Germans and largely Germanized so that the only group which retains its Slavic language is the Wends of Lusatia. The first part of the book describes their culture, the efforts of the Germans to assimilate them and the counter-efforts of the Czechs and others to secure their independence or autonomy.

In 1854 a group of Lutheran Wends who did not relish the union of the Lutheran and Reformed churches which had been decreed by the Prussian Government, emigrated to Texas. The second part of the book gives the history of their settlements in this new environment. As most of their fellow-Lutherans in America are German in origin the Texan Wends have gradually become Germanized, although some of them can still speak Wendish.

ISAAC NEWTON. *A Biography*. 1642-1727. By Louis T. More. *Charles Scribner's Sons, New York*. \$4.50. 9 x 6; xii + 675; 1934.

This is not a book to be read hurriedly. Professor More (of the Graduate School of the University of Cincinnati) has gathered within its covers a vast amount of material concerning this great genius, gleaned it from published works, from the great collections of Newton's personal and unpublished papers in the possession of the Countess of Portsmouth and of Viscount Lymington, and from the Newton papers in the University of Cambridge. Without doubt it is the most complete and authoritative record yet to appear. Since the writer has delved so thoroughly into all facts and occurrences which pertained to the development of Newton as scientist, philosopher, politician, financier and theologian, parts of the volume will seem dull to the average reader of biography. Yet for a complete and critical understanding of the life and character of Newton this was necessary. The task of writing the book was doubly difficult by the fact that even before Newton's death he had been exalted into a superman,—"a national monument to the glory of England." The book is thoroughly documented and indexed.



A SCIENTIST IN THE EARLY REPUBLIC, SAMUEL LATHAM MITCHILL, 1764-1831.

By Courtney R. Hall. *Columbia University Press, New York*. \$2.50. 9 x 6; vii + 162; 1934.

A biography that doesn't read like the case history of a psychopathic patient is news. There are no complexes, neuroses, or fixations in this one. Unless maybe Mitchill had a fixation on joining learned societies. He really was the "Fellow of forty-nine societies" as he was reputed to be in a poem by Joseph Rodman Drake. Mitchill was a physician, chemist, geologist, paleontologist, zoologist, botanist, linguist, and poet. He was the founder and editor of the first medical journal in this country. He was a professor at Columbia College, a member of the New York State Legislature, and of both houses

of the Federal Congress. He helped clarify the situation in regard to oxidation with which the chemists were struggling, made it possible for Livingston and Fulton to experiment with their steam boat on the internal waters of New York, and he wrote a guide book to New York City. In his rôle as medical man—he was staff physician of the New York Hospital for 20 years—he was particularly interested in all epidemic diseases, both as to treatment and prevention.



STERILIZATION? BIRTH CONTROL? A Book for Family Welfare and Safety.

By Helen Macmurchy. The Macmillan Co. of Canada, Toronto. \$1.50. 7½ x 5; 156; 1934.

The book is divided into two parts. The first deals with sterilization and the second with birth control. After giving a summary of the history of the sterilization movement, the author reviews the present status of sterilization in several of the large countries of the world. She makes no particular plea for sterilization of the mentally and physically defective, though realizing the importance of state control, but she feels that segregation is on the whole as effective and makes the patient happier. Her attitude towards birth control is summed up as follows: "Birth Control or contraception is not a normal thing. It should not be undertaken or carried on except for clear, definite or grave reasons, of a medical nature and under medical advice." Nothing very new or original comes out of the book.



THE QUEST FOR CORVO: An Experiment in Biography.

By A. J. A. Symons. Macmillan Company, New York. \$2.50. 8½ x 6½; xiv + 293; 1934.

Many of the readers of that strange novel *Hadrian the Seventh* must have wondered what manner of man the author was. Mr. Symons not only wondered but resolved to find out and this book is the record of his quest and its results. *Hadrian the Seventh*, it turns out, is in part auto-

biographical. Not that Rolfe, the self-styled Baron Corvo, was ever elected Pope, but that George Arthur Rose, earning a precarious living by writing, by painting, by photography, persecuted by his fellow Catholics, but firm in his conviction of his vocation for the priesthood, is Rolfe seen through his own eyes. As to the persecutions his acquaintances might have told another story. Rolfe was a true son of the horse-leech, who sucked his victims dry and then apparently quite genuinely felt himself injured because they could no longer afford him sustenance. Friendship with him was "a minor experiment in demonology."



IRON IN THE FIRE.

By Edgar Morrow. Angus and Robertson, Sydney. 6 shillings. 7½ x 4½; ix + 268; 1934.

Advertised as a war book which may be "read aloud in any company," this account of the Australian infantryman is not insipid by any means. It is a chronological account compiled from memory, letters, and what must have been a remarkable diary. There is no attempt at analyzing causes or results of war but the book sticks to the experiences of one common soldier. The "heads" come in for considerable criticism concerning the movement and general management of troops. The really unusual and amazing thing about this book is the way the author makes you feel with him his constantly fluctuating emotions about the war, depending upon how far away the enemy is. When the author is in the line his only thought is to get out as soon as possible, but when he is on leave in England and rather lonely, the war doesn't seem so bad.



THE FAMILY.

By M. F. Nimkoff. Under the Editorship of William F. Ogburn. Houghton Mifflin Co., Boston. \$3.00. 8 x 5½; x + 526; 1934.

This book is arranged as a text for college use. There are twelve chapters, the first

two of which describe in general the nature of the family as a social institution. The following chapters are devoted to the development of the family from early times to the present day. In the light of this history of the changes that have taken place in the family the student is led into the study of the modern American family—its biological, economic, social and personal aspects. The last chapters are concerned with what breaks down family life, and how family guidance clinics can help avert such catastrophes. At the end of each chapter there is a list of selected readings, topics for study and questions for discussion.



WORLD CIVILIZATION.

By Hutton Webster and Edgar B. Wesley.

D. C. Heath and Co., Boston. \$2.12.

7½ x 5½; xxiv + 844 + 18 plates; 1934.

An excellent high school text-book for a one year course in world history. The authors have traced in broad outlines the development of civilization rather than the details of the political history of various countries. In addition to the text the 22 chapters conclude with a suggested glossary, review questions, discussion questions, projects and activities, source readings and selected bibliographies. In a series of appendices are given additional data concerning selected bibliographies and a list of dates and events especially useful for review work and in helping to build the necessary chronological framework. The volume is profusely illustrated and contains a combined index and pronouncing vocabulary.



PETIT HISTORIQUE DE L'AFFAIRE DE GLOZEL.

By A. Morlet. G. Desgrandchamps, Paris.

12 francs. 7½ x 4½; 207; 1932 (paper).

The author of this book, who first described the archaeologic discoveries (?) made at Glozel, gives his version of that highly odoriferous *affaire*. He states that doubt as to the authenticity of the Glozel findings was inspired by the caretakers of the archaeologic museum at nearby Vichy.

They were losing financially from lack of visitors whose interest had shifted to Glozel and the author alleges that they bribed the chief of the French judiciary police to give false evidence of fraud. It is on this man, now dead, that the author vents most of his ire. In the form written, this is not a publication that will add scientific prestige to Dr. Morlet.



MAN OF AFRICA.

By Samuel Y. Ntara. Translated and Arranged from the Original Nyanja by T. Cullen Young. Religious Tract Society, London. 3s. 6d. net. 7½ x 4½; 181;

1934.

An anthropologic and psychologic study of the Chewa tribe of Nyasaland, Africa. The author tells his story as a narrative by taking as the subject one Nthondo, of the above tribe, and following his career from birth until pneumonia terminated his tribal chiefship. The book originally appeared in the Nyanja language and has been smoothly translated into English. It gives an interesting, and no doubt authentic, account of the customs of these people. Julian Huxley has contributed a foreword.



ONE'S COMPANY. A Journey to China.

By Peter Fleming. Charles Scribner's Sons, New York. \$2.75. 8½ x 5½; 319 + 16 plates; 1934.

Peter Fleming is a young English journalist with a keen sense of humor, remarkable powers of observation and a love of adventure. These qualities combine to make his book most entertaining reading. He travelled across Siberia to Manchuria where he hunted bandits with the Japanese and then went south to the Communist district. His conclusions of a political nature are interesting, but the chief value of the book lies in the picture it gives of the life of the people. The author's photographs which are used as illustrations are excellent, as is the map on which his route is shown.

A HISTORY OF MARRIAGE AND THE FAMILY.
Revised Edition.

By Willystine Goodsell. *The Macmillan Co., New York.* \$3.50. 7½ x 5; xx + 590; 1934.

A summary of the different marriage and family customs and laws in successive historical periods and those observed in some primitive societies. In particular, the author traces the individual position occupied by father, mother and children in the Hebrew, Greek and Early Roman periods, in the Roman empire and so on up to the twentieth century. The problems resulting from the social conditions of the United States at present are discussed at length.

A list of collateral reading (all in English) is given at the end of each chapter and there are all the requirements sufficient to classify this as a satisfactory textbook.



VERERBUNGSLEHRE, RASSEN-, BEVÖLKERUNGS- UND FAMILIENKUNDE. *Für die Abschlussklasse der Mittelstufe höherer Lehranstalten.*

By Albert Bauer. *G. Freytag, Leipzig.* 1.40 marks. 9½ x 6½; 78 + 2 plates; 1934 (paper).

Believing that the national-socialistic state is built up on a human biological basis, the author is engaged in writing a graded series of books on this subject for use in the schools. The present volume is intended for the intermediate classes of the higher schools, and for those who, having completed their formal education, wish to read up on the subject. As the title indicates the ground covered includes genetics, anthropology, demography, eugenics and methods of collecting genealogical data. There are numerous illustrations and an index.



STORY OF THE SPANISH MISSIONS OF THE MIDDLE SOUTHWEST. *Being a Complete Survey of the Missions Founded by Padre Eusebio Francisco Kino in the Seventeenth Century and Later Enlarged and Beautified by the Franciscan Fathers During the Last Part of the Eighteenth Century.*

By Frank C. Lockwood. *Fine Arts Press, Santa Ana, Calif.* \$4.00 net. 9½ x 6½; vi + 78 + 30 plates; 1934.

Dr. Lockwood has visited each of the missions founded by Father Kino, a Jesuit missionary and explorer of the seventeenth century, in southern Arizona and northern Mexico. In this book he gives their location and history as a supplement to the life of Kino already published. It is written so that it may be used as a guide-book by the tourist, giving distances and directions. There is a good map and lithographed illustrations.



NEW SOURCES OF INDIAN HISTORY 1850-1891. *The Ghost Dance. The Prairie Sioux. A Miscellany.*

By Stanley Vestal. *University of Oklahoma Press, Norman.* \$4.00. 9 x 6; xix + 351 + 13 plates; 1934.

This is a collection of source material made by the author while doing research for his biography of Sitting Bull. It includes hitherto unpublished documents setting forth "the views of officials of the Indian Bureau, officers of the United States Army, Sioux Indians, and white citizens" which deal with the Ghost Dance, Sitting Bull and the history of the Sioux Indians. The elaborate table of contents serves as an index and there are maps and illustrations.



THE BIOLOGY OF THE INDIVIDUAL. *An Investigation of the Most Recent Advances. The Proceedings of the Association, New York, December 28th and 29th, 1933.*

By Association for Research in Nervous and Mental Disease. Editorial Board: J. Ramsay Hunt, Thomas K. Davis, Angus M. Franz. *The Williams & Wilkins Co., Baltimore.* \$6.00. 9 x 6; xv + 323; 1934.

A symposium contributed to by nineteen persons. With one exception, the individual whose biology is considered is human. The exception is introduced by means of a report on breed-crosses of dogs carried on by Stockard and his associates and presented by James. The rest of the

papers may be classified roughly as dealing with bodily habitus, growth, endocrines, and more strictly psychological aspects of the individual. There is an index and a list of members.



A DECADE OF PROGRESS IN EUGENICS. *Scientific Papers of the Third International Congress of Eugenics Held at American Museum of Natural History, New York, August 21-23, 1932.*

Committee on Publication: Harry F. Perkins, Chairman; Charles B. Davenport, Ex Officio; Clarence G. Campbell; Madison Grant; Harrison R. Hunt; Frederick Osborn; Paul Popenoe; Laurence H. Snyder; Harry H. Laughlin, Secretary. The Williams & Wilkins Co., Baltimore. \$6.00. 9 x 6; xi + 531 + 32 plates; 1934.

This volume consists of an introduction, 65 papers, a description of the exhibits at the Third International Congress of Eugenics, and a list of members. The papers are for the most part extremely short with very few references to the literature. They are grouped into 8 sections drawn from many phases of anthropology, genetics, and eugenics. A considerable number of the papers are reformative in tone but there are a few that are purely objective.



KÖRPERFORM, WESENSART UND RASSE. *Skizzen zu einer medizinisch-biologischen Konstitutionslehre.*

By Walther Jaensch. Georg Thieme, Leipzig. 4.80 marks. 9½ x 6½; 88; 1934 (paper).

A study of constitutional type and personality, with particular reference to the distinct groups inhabiting Germany. The book is divided into three parts: Race and constitution; Constitutional research and the clinic (in which W. Schulz collaborates with the author); and Outlook on eugenics and race hygiene. This work, like so many of the current German scientific publications, takes on a political tinge, which seems a pity.

ALLGEMEINE KONSTITUTIONSLEHRE IN NATURWISSENSCHAFTLICHER UND MEDIZINISCHER BETRACHTUNG. *Zweite Auflage.*

By O. Naegeli. Julius Springer, Berlin. RM. 15 (Paper); 16.20 (Cloth). 9½ x 6½; vii + 190; 1934.

The second edition of this work on Human Constitution amplifies somewhat the contents of the previous edition (reviewed in Volume 3, Number 1 of this Journal) without altering its form or style. One notes especially that the section on genetics has been brought up to date and summarizes very well the more recent observations.



HYPNOTISM IN THE TREATMENT OF DISEASE: ITS SCOPE. *A Plea for Research.*

By B. Layton Lloyd. John Bale, Sons and Danielsson, London. 3s. 6d. net. 7½ x 4½; v + 44; 1934.

Dr. Lloyd feels that the advantages of hypnosis for anesthesia and for the treatment of functional paralysis and blindness, constipation, insomnia and other conditions are not sufficiently realized by most physicians.



A TABULAR SUMMARY OF STATE LAWS RELATING TO PUBLIC AID TO CHILDREN IN THEIR OWN HOMES. *In Effect January 1, 1934.* U. S. Department of Labor, Children's Bureau, Chart No. 3.

Government Printing Office, Washington. 10 cents. 10½ x 8; 40; 1934 (paper).

STUDENT'S STUDY GUIDE to Critical Appreciation of the Photoplay Version of Robert Louis Stevenson's *Classic of Adventure, Treasure Island.*

TEACHER'S KEY to Accompany the Student's Guide to Critical Appreciation of the Photoplay Version of Stevenson's *Treasure Island.*

By William Lewin. Published for the National Council of Teachers of English. Bureau of Publications, Teachers College, Columbia University, New York. Packets of 30 copies of Student's Study Guide with a key for the teacher, \$1.00 per packet. 9 x 6; Guide, 7, Key, 14; 1934 (paper).

UNEMPLOYMENT RESERVES. Study-Outline. Pertinent Questions. List of References.

Prepared under the direction of Samuel W. Reyburn, Chairman. Retail Merchants Committee on Unemployment Legislation, 366 Fifth Ave., New York. 8 x 5½; 24; 1934 (paper).

PREHISTORIC ELEMENTS IN OUR HERITAGE. Bulletin of the John Rylands Library, Vol. 18, No. 2.

By H. J. Fleure. Manchester University Press, Manchester. 1 shilling net. 10½ x 6½; 36; 1934 (paper).

BIBLIOGRAPHY ON LAND SETTLEMENT with Particular Reference to Small Holdings and Subsistence Homesteads. U. S. Department of Agriculture Miscellaneous Publication No. 172.

Compiled by Louise O. Bercaw, A. M. Hannay, and Esther M. Colvin, under the direction of Mary G. Lacy. U. S. Government Printing Office, Washington. 50 cents. 9½ x 5½; iv + 492; 1934 (paper).



ZOOLOGY

SEA TERNS OR SEA SWALLOWS. Their Habits, Language, Arrival and Departure.

By George and Anna Marples. Country Life, London. 15 shillings net. 9¾ x 7½; xii + 227 + 58 plates; 1934.

This is a "nature book" that in addition to its beauty and charm makes a contribution of real significance and importance to scientific natural history. Mr. and Mrs. Marples are amateurs, in the sense that they do not get their living by professionally practising zoölogy. But they have developed their hobby in a close and useful alliance with that science. As a result they have attempted in this volume a complete monograph of British Terns, to appeal equally to the nature lover and the scientific man. The result, while not perfect, is extremely good. It embodies great masses of original data based on the authors' own observations on structure, habits, behavior, distribution, etc., and is illustrated profusely with the most beautiful, clear, precise and significant set of photographs we have ever seen of any animal under natural conditions. Their assembling must have cost an

infinity of patience as well as technical skill.

The book opens with a detailed historical and systematic account of the species found in Great Britain, and how they may be recognized. Then, after a description of the terneries and distribution of the species among them, follow chapters on arrival and departure, occupation, courtship and marriage, tracks (and the use of track records to build up an understanding of courtship and other behavior that cannot be directly observed because occurring at night—all this reading like an uncommonly good detective story), nests, eggs, and young, food, attacks and defense, panics, experiments, vocabulary, removals and desertions, atmosphere and environment. There is an excellent index, but from a bibliographic viewpoint the book is weak, in a technical professional sense. While the authors evidently know the British literature fairly well, they are not aware of what has been done in other countries. A conspicuous example is found in the absence of any reference to the important observational and experimental work of John B. Watson. But so valuable a book can safely stand on its own positive contributions. Every library of zoölogy and comparative psychology must have this work on its shelves.



THE RÔLE OF ENVIRONMENT IN THE LIFE OF BIRDS. Contribution No. 28 from the Baldwin Bird Research Laboratory, No. 449 from the Zoological Laboratory of the University of Illinois.

By S. Charles Kendeigh. University of Illinois, Urbana. 10 x 6½; 117; 1934 (paper).

In this monograph the author takes the eastern house wren (*Troglodytes a. aedon* Vieillot) as a typical member of the deciduous forest community of the eastern United States and attempts to analyze the reactions of this species to various ecological factors. In other words, the community is studied by learning as much as possible about a common member of that community. Various environmental factors such as temperature, relative humidity, solar radiation, etc., are studied as they affect the migration, distribution,

and abundance of the wren. Temperature receives most of the experimental emphasis and, as a result of his experiments, Ken-deigh concludes that, for high temperatures, it is the maximum temperature reached during the day which is of greatest ecological importance in the economy of the bird. For low temperatures, the mean night temperature and the duration of darkness are concluded to be the most important.

On the whole, this study is a competent one and should prove a valuable addition to ecological and physiological literature. The author lists a lengthy bibliography and commendably uses it in his text. It is regrettable that the data are not possessed of the usual biometric constants so that sampling errors could be evaluated. It may be that the author took these into account but, if so, his readers have no knowledge of it. In the section dealing with rate of metabolism the reviewer feels the paper would have been strengthened by experimentally determining this rate directly instead of using the loss of weight of the bird as a criterion.



INSECT PHYSIOLOGY.

By V. B. Wigglesworth. Methuen and Co., London. 3s. 6d. net. $6\frac{3}{4} \times 4\frac{1}{4}$; x + 134; 1934.

Here is a welcome and excellent little book on insect physiology. It gives authoritative information about the physiology of the integument, respiration, circulation, digestion, excretion, nutrition and metabolism, reproduction and growth, and nervous functions of insects in general. Practically each fact discussed is accompanied by a specific reference which permits the reader to study further if he so desires—this is an admirable aid. The author has drawn on diverse orders of the insects for his illustrative material so that the volume presents as well-rounded a story as the available data allow. Physiologically-minded biologists, after going through this volume, will feel more than ever that fascinating problems and possible solutions await them in the field of insect physiology.

STUDIES ON SOME PROTOZOAN PARASITES OF FISHES OF ILLINOIS. *Illinois Biological Monographs, Vol. XIII, No. 1.*

By Richard R. Kudo. University of Illinois Press, Urbana. 75 cents. $10\frac{1}{2} \times 7$; 44; 1934 (paper).

This paper is divided into two parts. The first presents the results of a preliminary study of fishes of Illinois belonging to thirty-five species with reference to their protozoan parasites. These fishes belong to thirteen families, of which Catostomidae, Cyprinidae, and Siluridae were found to be common hosts to histozoic protozoan parasites. An unusual case of *Ichthyophthirius* infection in carp is noted. In the second part nineteen new species of Myxosporidia are studied and described, and additional information on four known species of Myxosporidia is given. Included in the paper is a brief bibliography, a group of plates and figures, and an index.



MACROLEPIDOPTERA AND THEIR PARASITES REARED FROM FIELD COLLECTIONS IN THE NORTHEASTERN PART OF THE UNITED STATES. *U. S. Department of Agriculture Miscellaneous Publication No. 188.*

By J. V. Schaffner, Jr., and C. L. Griswold. U. S. Government Printing Office, Washington. 15 cents. $9\frac{1}{8} \times 5\frac{7}{8}$; 160; 1934 (paper).

The present volume is the result of studies begun in 1915 to determine the native hosts of the introduced parasites of the gypsy and brown-tail moths. In addition to information on this point, a good deal was learned about the native Lepidoptera and their parasites. A number of parasitic forms new to science have been found. But most noteworthy is the collection of data which makes possible the listing of the Lepidoptera with their food plants, area of occurrence, information about life cycle, and their parasites. The material is also listed from the opposite point of view—that is, by parasite, with host forms given for each parasite.



LAIKAN. *The Story of a Salmon.*

By Joseph Wenter. Translated from the

German by Charles Ashleigh. Rich and Cowan, London. 6 shillings net. 7½ x 4½; vii + 241; 1934.

A fascinating story of the experiences of a young salmon from the time of his birth to his death twenty years later. The writer draws a romantic picture of the struggles and pleasures of *Laikan* in rivers and pools, his comrades and his enemies, his growing up and journeys to the sea and return to the waters of his birth. A book which will appeal particularly to the young reader of from 12–18 years of age who likes scientific facts diluted with plenty of fiction. The book is without index. Major Josslyn S. Egerton of England contributes a foreword.



ÜBER DEN GESCHMACKSSINN DER BIENE. *Ein Beitrag zur vergleichenden Physiologie des Geschmacks. Zeitschrift für vergleichende Physiologie, 21. Band, 1. Heft.*

By K. von Frisch. Julius Springer, Berlin.

19.80 marks. 9½ x 6½; 156; 1934 (paper). The researches indicate that bees can distinguish the tastes of sugar, hydrochloric acid, cooking salt, and quinine. The value of the threshold of taste appears to be influenced by various conditions. Uniformly a 17.1 percent solution of cane sugar is detected by the bees, however, a 8.5 percent solution is detected by only half of the bees, and practically always a 4.25 percent solution is refused. The threshold differs among individual bees, and changes with increase in age so that the taste becomes less keen with advancing age. Finally, as in man there exists the phenomenon of fatigue of taste sense.



ESKIMO YEAR. *A Naturalist's Adventures in the Far North.*

By George M. Sutton. The Macmillan Co., New York. \$3.00. 8½ x 5½; xii + 321 + 12 plates; 1934.

This is an account of the year the author spent on Southampton Island, situated in the mouth of Hudson Bay. It is written chronologically and tells of the life of the people, their games, customs and festivities. The author gets to know many of

them well and goes on hunting trips of all kinds. He is particularly interested in the animal and bird life and describes the habits of bears, seals, walrus, foxes, whales, caribou, lemmings and many others. There is a great deal of valuable material in this book, but it could have been made more interesting.



BIOLOGIE DER WASSERINSEKTEN. *Ein Lehr- und Nachschlagebuch über die wichtigsten Ergebnisse der Hydro-Entomologie.*

By H. H. Karny. Fritz Wagner, Vienna.

16 marks. 9½ x 6½; xv + 311; 1934 (paper).

No doubt this book will be welcomed by European limnologists since it gives a good account of the biology, taxonomy, anatomy, and general natural history of many aquatic insects. The volume contains systemic keys which aid the student in determining his specimens, and also many sketches of the forms studied and their habitats. A useful book.



VERTÉBRÉS INFÉRIEURS (*Poissons, Batraciens, Reptiles*). *Actualités Scientifiques et Industrielles 183. Leçons de Zoologie et Biologie Générale VI.*

By Georges Bohn. Hermann et Cie, Paris.

15 francs. 10 x 6½; 96; 1934 (paper).

A not-too-impressive account of the natural history, comparative anatomy, and phyletic relationships of the lower vertebrates—fish, amphibia and reptiles. The material seems too sketchy to be of much use to serious vertebrate students although it might be useful to people interested in a general orientation about these animals.



VON OTTERN UND NATTERN. *Ein Schlangenbuch.*

By Hanns Wetzell. Gustav Wenzel, Braunschweig. RM. 3.50. 8½ x 5½; 148; 1934.

The author, a naturalist and snake-lover, writes charmingly about the natural history of snakes, particularly of the species indigenous to Germany, their

care and feeding in captivity, and their treatment in art, lore and modern literature. The book is designed for the layman. The illustrations are well chosen and excellently reproduced.



VETERINARY HELMINTHOLOGY AND ENTOMOLOGY. *The Diseases of Domesticated Animals Caused by Helminth and Arthropod Parasites.*

By H. O. Mönnig. William Wood and Co., Baltimore. \$9.00. 9½ x 6½; xvi + 402; 1934.

An excellent textbook designed for veterinary students and practitioners. The most important parasites of all of the important domesticated animals of all countries are described with illustrations. Descriptions of life cycles are included in practically every case.



THE ANIMAL PICTURE BOOK.

By H. Mortimer Batten. Thomas Nelson and Sons, New York. \$3.00. 10½ x 7½; vi + 129; no date.

Sixty-four very decorative colored pictures with popular descriptions of the habits of the mammals depicted.



AN ANNOTATED BIBLIOGRAPHY OF THE HESSIAN FLY PHYTOPHAGA DESTRUCTOR (SAY). U. S. Department of Agriculture Miscellaneous Publication No. 198.

By J. S. Wade. U. S. Government Printing Office, Washington. 10 cents. 9½ x 5½; 100; 1934 (paper).



BOTANY

THE PHYSIOGRAPHY AND VEGETATION OF TRINIDAD AND TOBAGO.

By R. C. Marshall. Oxford University Press, New York. \$2.25. 10½ x 7½; 56 + 10 plates; 1934.

In the opinion of Mr. Marshall, who is Conservator of Forests on these islands, "there is only one really satisfactory way

of assessing the finer divisions of forest types, and that is by the method of strip surveying. In the course of routine departmental work more than 16,000 chains of line have been run during the last few years, all trees half a chain either side of the lines being enumerated by species and girth, and a note taken every chain of the soil down to one foot." The ecological results of this survey are set forth in admirable fashion in the form of descriptions of the various forest types and their successional relationships, maps, floristic lists, and photographs, and these data are accompanied by numerous maps showing the topography, geology and soils, temperature and humidity, and rainfall of the islands. "It is probable that in its virgin conditions, rain forest along with its edaphic climax variations covered over 90 per cent of the colony: to-day the area is between 40 and 50 per cent owing to the clearing of land in the interests of agriculture." One of the interesting features of the book is the argument Marshall advances that land once so cleared may not return to the original type of climax forest but instead may pass through a "deflected succession" to an "entirely different type of vegetation sufficiently stable to be termed a climax." It appears from early records that one such "deflected climax," a type of savannah, has been stable for at least 300 or 400 years.



CONTRIBUTION À L'ÉTUDE DES BACTÉRIES BLEUES ET VIOLETTES.

By Pierre Godfrin. Faculté de Pharmacie de Nancy. 40 francs. 9½ x 6½; xvi + 268 + 10 plates; 1934 (paper).

The results of two years' work in the Department of Bacteriology are here presented to the Faculty of Pharmacy of Nancy as a thesis for the degree of doctor of pharmacy. In a preliminary chapter is outlined the plan adopted by the author for identifying and classifying bacteria in microbiology according to their morphology (by examination in the natural state, including a study of dimensions, motility, form and mode of grouping and natural coloration of the plastids, and examination after staining to show the

structure of the plastids); the action of physical, chemical and biologic agents; agglutination; and physico-chemical character of suspensions. Then follow the three main parts of the work: The first describing and classifying, by the previously outlined plan, the bacteria producing blue and violet pigments; the second devoted to the bacterial chromogens; and the third to a discussion of the more important classifications in the literature (which are far from being in accord) and variations in bacteria. There is a bibliography of sixteen pages.



TREES OF TRINIDAD AND TOBAGO.

By R. C. Marshall. *Conservator of Forests, Port-of-Spain, Trinidad.* 3 shillings. 9 x 5½; x + 101 + 20 plates; 1934 (paper). This manual was written for the guidance of foresters in Trinidad and Tobago and consists of brief descriptions of the native forest trees.

In writing descriptions emphasis has been laid on characteristics of bark, leaf and fruit, and the flowers have been relegated to a relatively minor position.

Bark and leaf are the easiest to observe in the forest, and fruits lying on the ground are often the first indication of a given species. Once flowers have fulfilled their function of enabling the species to be botanically identified they often largely lose their interest for the worker in the woods who is more concerned with some factor always to hand.

The Leguminosae have by far the greatest number of species, 57, and the Myrtaceae and Lauraceae come next with 21 and 20, respectively.

There are a number of illustrations, not very well reproduced, and a complete index.



ECONOMIC PLANTS.

By Ernest E. Stanford. *D. Appleton-Century Co., New York.* \$5.00. 8½ x 5½; xxiii + 571; 1934.

This is a valuable reference book as well as an unusually well-written textbook of economic botany. The longest section, 70 pages in length, is devoted to food products, exclusive of vegetables, the only important omission in the book. Nearly as much space is given over to a discussion of the nature, treatment, and uses of wood.

The sections on fruits, plants yielding proteinaceous products, textile plants, rubber, and the one dealing with resins, tanning materials, and cork are 30 to 50 pages long. There are 20-page sections dealing with medicinal plants, beverage yielding plants, spices, fixed oils, sugar and sugar plants, and paper and pulp, and a shorter chapter on volatile oils. The author has succeeded very well in emphasizing the items that make the readiest appeal to human interest without sacrificing the botanical significance of the sources of these products and the economic consequences of their use. The illustrations are numerous and well-chosen, and there are numerous maps showing the centers of production of plant products. There is a detailed table of contents and an excellent index.



HANDBUCH DER ERNÄHRUNG DER LANDWIRTSCHAFTLICHEN NUTZPFLANZEN.

By J. Becker-Dillingen. *Paul Parey, Berlin.* 19.60 marks. 9½ x 6½; viii + 523; 1934.

This treatise on the use of fertilizers in modern agricultural practice is intended for workers in agricultural experiment stations and a number of features make it a useful reference book. After an exposition of the basic principles of plant nutrition and soil science involved, the fertilizer requirements of a large number of field and truck crops are discussed individually, the relevant literature is reviewed, and specific recommendations are made. The illustrations are unusually instructive. Many of them are diagrammatic and illustrate basic principles very effectively. There are sets of excellent colored plates, 11 in all, showing the symptoms of different types of mineral deficiency in oats, sugar beets, potatoes, clover, and tobacco. Graphs showing increase in dry weight, and the amount of mineral nutrients absorbed at different stages in the growth period are provided for a large number of crop plants and are so cleverly done as to invite imitation. A great deal of data on the chemical composition of fertilizers and plant products is presented. There is an index, and bibliographic references appear as footnotes.

L'ÉPIDERME DES GRAMINÉES. *Étude Anatomique et Systématique.*

By Henri Prat. Masson et Cie, Paris.

9½ x 6½; 207 + 4 plates; 1931 (paper).

For purposes of classification the epidermal cell of the Gramineae may be divided into a relatively small number of groups: silico-suberized, exodermic, and homogeneous, and these groups may be further subdivided according to length, waviness of cell wall, and other characteristics. Prat proposes a system of notation for these types and arrives at the conclusion that they constitute a valuable means of distinguishing species in instances where the usual methods of taxonomy give uncertain results. In particular, he treats the species of *Agropyrum* to show how the method can be used for distinguishing species, and the cereal grains to show how the study of epidermal characters can be used to supplement floral analysis.

The book is well illustrated and there is an extensive bibliography but no index. This work originally was published in the *Annales des Sciences Naturelles*.



DIE PFLANZENGEOGRAPHISCH-ÖKOLOGISCHEN GRUNDLAGEN DES WALDBAUS. *Dritte, völlig umgearbeitete Auflage.*

By K. Rubner. J. Neumann, Neudamm.

RM. 36 (bound); RM. 34 (paper).

9½ x 6½; xiv + 597 + 8 maps folded in cover; 1934.

The third, revised edition of this excellent text and reference book is an introduction to the ecological basis on which sound forest management depends, and there is no reason why it should not be as useful to ecologists as it is to foresters for its clear presentation of the fundamentals of plant ecology and for its extensive data on the natural distribution of forest tree species and forest types of Europe.

The first part of the book (about 275 pages) is an analysis of the climatic and edaphic factors that are effective in tree growth, the second part (about 170 pages) deals with the geographic range of forest types in Europe, and the third part (about 200 pages) deals with forests considered as plant communities and the significance of competition. There are numerous well-

chosen maps and photographs; bibliographic references appear as footnotes, and there are author and subject indexes.



L'EMBRYOLOGIE VÉGÉTALE. *Résumé Historique. 1^{re} Époque: Des origines à Hanstein (1870). Actualités Scientifiques et Industrielles 142. Exposés d'Embryologie et de Morphologie Végétales. I.*

By René Souèges. Hermann et Cie, Paris.

12 francs. 10 x 6½; 57; 1934 (paper).

In this important contribution to the history of science Souèges traces the development of the knowledge of the reproduction of plants through three historical periods. In the first one, beginning in antiquity and ending in the last years of the seventeenth century, the concept of sexuality of plants was formulated and established. In the second period, ending about 1822-26, the concept of fertilization developed although it was based largely on macroscopic observation. By the end of the third period, however, just before the epochal discoveries of Hanstein and Strasburger, it was known that the embryo arose from one of the three vesicles which occupy the summit of the embryo sac. All this had to be learned before the study of embryology could begin. Souèges treats the contribution made by individual workers in these three periods adequately, interestingly, and with full documentation. The bibliography covers more than eight pages.



WILD FLOWERS.

By Homer D. House. The Macmillan Co., New York. \$7.50. 11½ x 9; 362 + 264 plates; 1934.

These color photographs of flowering plants are easily the best to be found in any popular botanical book and the color of flowers and foliage is reproduced with remarkable fidelity. These illustrations were first issued by the New York State Museum in an edition that is now exhausted. For each species there is a brief, botanical description and a statement as to its distribution, and for 364 species there are color photographs. There are also a

number of black and white photographs. There is a list of illustrations arranged by families, and an index of popular and scientific names of plants.



LA MULTIPLICATION VÉGÉTATIVE et le Bourgeonnement chez les Plantes Vasculaires. *Actualités Scientifiques et Industrielles* 134. *Exposés de Biologie Végétale*. I.

By Pierre Chouard. Hermann et Cie, Paris. 10 francs. 10 x 6½; 48; 1934 (paper).

Chouard has undertaken a formal classification of the ways in which plants increase in number without the intervention of the sexual process, illustrating each type by a number of examples, and usually by a drawing. He argues forcibly and plausibly for restriction of the term *reproduction* to sexual multiplication and for restriction of the use of the word *regeneration* to the rare cases in the plant kingdom in which there actually is a replacement of a missing part. There is a good bibliography and a table of contents. It is a valuable contribution to plant morphology.



POPLARS, PRINCIPAL TREE WILLOWS AND WALNUTS OF THE ROCKY MOUNTAIN REGION. *United States Department of Agriculture Technical Bulletin* No. 420.

By George B. Sudworth. U. S. Government Printing Office, Washington. 10 cents. 9 x 5½; 111; 1934 (paper).

This work is one of a series of monographs on the systematic dendrology of western trees prepared by the late Mr. Sudworth. For each species of the genera *Populus*, *Salix*, and *Juglans* there is an excellent illustration of flowers and foliage, a distribution map considerably more detailed than any we have seen before, and a thorough description which includes information useful to taxonomists, foresters, and naturalists. There are analytical keys for each genus and there is an extensive bibliography.



VON DER WILDPFLANZE ZUR KULTURPFLANZE. *Die Bedeutung der natürlichen und*

künstlichen Zuchtwahl für die Entstehung neuer Pflanzenrassen.

By Hermann Kuckuck. Alfred Metzner, Berlin. 2.80 marks. 8½ x 5½; 68 + 4 plates; 1934.

This is an interesting delineation of the origin and geographical distribution of some of the commoner cultivated plants, the genetical theories and methods involved in their culture, and problems and objectives of experimental work at the Kaiser-Wilhelm Institute for Plant Breeding. The book is intended for the layman, and the author makes no claim to its being comprehensive.



ÉTUDES SUR LES MOUSSES DE LA RÉGION DE MONTRÉAL. *Contributions du Laboratoire de Botanique de l'Université de Montréal*, No. 25.

By H. Dupret. Institut Botanique Université de Montréal, Montreal, Canada. 75 cents. 9 x 6; 70; 1934 (paper).

Dupret has provided ecological notes for 256 species of mosses found in the region of Montreal. There are drawings to accompany the description of a new species of *Hypnum* and of several new varieties and *formae*, and an excellent index.



WHEAT IN GREAT BRITAIN.

By John Percival. John Percival, Leighton, Shinfield, Reading, Berks. 10s. 6d. net. 8½ x 5½; 125 + 32 plates; 1934.

This volume will serve as an excellent reference to agriculturists. Descriptions and illustrations are given of about fifty different kinds of wheat. There is an interesting historical account of wheat growing from earliest times in Great Britain.



MORPHOLOGY

THE BRAIN AS AN ORGAN. *Its Postmortem Study and Interpretation.*

By Frederic Wertham and Florence Wertham. The Macmillan Co., New York. \$7.50. 9½ x 6; xv + 538 + 166 plates; 1934.

Such a long and extremely technical book

is not easy reading but this one seems quite considerate of the ultimate consumer. Adolf Meyer in the introduction characterizes the book as follows:

Anyone who works in the field realizes the great difficulty of rising above mere description and to a constructively critical evaluation of the findings and methods and their interpretation. It is along this line that the present volume takes the lead and is, as far as I can see, of unrivaled value. It brings to the reader a sense for fundamental principles of a sound critical attitude toward general and special pathology.

The authors feel that neuropathologists have become too much dominated by the obviously useful idea of functional localization and that the idea of the brain as an organ and not as something entirely different from any other tissue is a profitable one. There is a long discussion on dissection and histological technique before the chapters on interpretation. The section on "The Extent of the Normal" especially warmed the cockles of this reviewer's heart. There are 160 plates made by Florence Wertham reproduced by the aquatone process. Altogether this is a notable contribution to the literature of neurology.

Our only criticism is that the references to the literature that occur throughout the text are sometimes so incomplete as to make consultation with original sources difficult. There is a list of 117 selected references and an index.



THE ANATOMY OF THE SALAMANDER.

By Eric T. B. Francis. *With an historical introduction by F. J. Cole.* Oxford University Press, New York. \$9.00. 9½ x 6½; xxxi + 381 + 13 plates; 1934.

From the viewpoint of the experimentalist, the comparative anatomist, and the herpetologist the salamander is an important organism. The present volume on its anatomy should find many friends indeed among these folk. It impresses the reviewer as being a very competent and thorough piece of work. The author points out that most of the previous accounts of salamander morphology are replete with errors which have been corrected in this book as much as possible. The presentation of the subject is straight-

forward and conventional, the various systems being taken up chapter by chapter in the usual way. The book is somewhat novel for including a chapter on the lymphatics—that mysterious system so frequently referred to by comparative anatomists but so infrequently and inadequately dealt with. An admirable appendix completes the book.



THE SKELETON OF BRITISH NEOLITHIC MAN, Including a Comparison with that of Other Prehistoric Periods and More Modern Times.

By John Cameron. Williams and Norgate, London. 15 shillings net. 8½ x 5½; 272 + 16 plates; 1934.

A systematic compilation of skeletal measurements and anthropometric indices taken from the remains of neolithic man uncovered in England and Scotland. Where it has been possible, the author has compared his results with those obtained from the skeletons of other prehistoric and of more recent periods. He discusses their probable differences in appearance and habits.

Necessarily fragmentary as are the data, yet the author manages to present a clear picture of the changes in the physical aspect of the inhabitants of England and Scotland and their probable racial origin. The many interesting facts which are brought out in this study cannot be mentioned in a brief review. It need only be said that they are useful and necessary for the student of anthropology.



A TEXTBOOK OF HISTOLOGY. *Functional Significance of Cells and Intercellular Substances.*

By E. V. Cowdry. Lea and Febiger, Philadelphia. \$5.50 net. 10½ x 6½; 503; 1934.

The author concentrates on building up in the mind of the student a conception of the remarkable integration of the human body. Hence the arrangement of the book is around the blood vascular system—"the great integrator." He states: "the properties of each and every cell in the

body are directly dependent upon its heredity, the fluid about it, and the other cells associated with it and should only be investigated in this connection." He strives always to give a conception of cells and elementary tissues in their normal environments. The book is well written, and with much more acumen as to what are really the essentials in the study of histology than most texts on the subject.



ON THE EARLY DEVELOPMENT OF THE VASCULAR SYSTEM. *The Development of Blood and Blood-Vessels in the Chorion of Man.*

By B. H. Jägerroos. *Anatomical Institute of Helsinki, Finland.* 9 $\frac{1}{2}$ x 6 $\frac{1}{2}$; 86 + 2 plates; 1934 (paper).

This is a further contribution to this subject, based on 25 human abortuses ranging in age from three weeks to three months. The author subscribes to the diphyletic theory of the origin of erythrocytes. On this point as well as on the origin of blood vessels the evidence presented is doubtless as good as can be expected from abortion material dead or moribund an unknown period of time.



FORMGESTALTUNG IM TIERREICH.

By H. A. Stolte. *W. Kohlhammer, Stuttgart.* Rm. 1.35. 9 x 5 $\frac{1}{2}$; 27; 1934 (paper).

The material in this little brochure was presented as a lecture at the University of Tübingen. It deals with the mechanisms involved in early embryological development, and is based on the work of Speemann, Schleip, Mangold and Vogt.



PHYSIOLOGY AND PATHOLOGY

NUTRITION AND DISEASE. *The Interaction of Clinical and Experimental Work.*

By Edward Mellanby. *Oliver and Boyd, Edinburgh.* 8s. 6d. 8 $\frac{1}{2}$ x 5 $\frac{1}{2}$; xix + 171; 1934.

This book, based on the Croonian lectures which the author delivered to the Royal College of Physicians in June, 1933, has

for its main thesis the demonstration of the interaction of different experiences in the laboratory and in clinical work in the furthering of medical science. The six sections are as follows: Rickets; dental structure and disease; thyroid gland—simple and toxic goiters; nutrition and infection; nutritional influences on the nervous system—experimental work on animals; extension of experimental results on nerve degeneration to some other clinical conditions.

Summing up the value of combined experimental and clinical work the writer says:

(1) A clinical post tends to orientate the mind of the laboratory worker towards practical problems of disease, so that a laboratory observation is often interpreted along these lines: (2) It also helps in the interpretation of laboratory results and, by allowing a more comprehensive view of any biological problem, assists in the appraisal of new facts and gives the opportunity of a saner interpretation of new phenomena: (3) a clinical interest suggests new problems for solution in the laboratory: (4) clinical research has in recent years disclosed new chemical agents and new problems of great physiological interest.

On the other hand

the animal experiments and laboratory remain the points of greatest importance, for it is mainly by means of these that the investigator discovers new phenomena and gets new ideas for clinical trial and application.

The volume is illustrated with photographic plates, figures and contains also tables and graphs. It is well documented but not indexed.



PERMÉABILITÉ CELLULAIRE ET PROBLÈME DU CANCER.

By W. Kopaczewski. *E. Le François, Paris.* 40 francs. 10 x 6 $\frac{1}{2}$; 166; 1934 (paper).

This is an example of rigorous rationalization within the limits of facts. The author critically reviews and synthesizes the results of his experiments and those of many others regarding the structure and nature of the cellular membrane and of the physical and chemical factors in its permeability.

The changes in permeability observed at different stages in the vital cycle of cells

lead him to the conclusion that the process of neoformation is accompanied by increased permeability of the membrane and is accompanied by a stabilization of the intercellular and humoral protoplasmic system. From this he is enabled to reach an hypothesis regarding cancer which can be summarized as follows: The greater permeability of new formed cells will permit penetration of foreign substances or an increased quantity of "normal" matter, the cell must therefore increase the speed of its vital cycle; and if such external conditions remain all new cells will continue in this accelerated growth.

At all times the author stresses that this is only an hypothesis, neither final nor all-explaining, but nevertheless justifying more extended experimentation. The author's hypothesis is not original in many of its aspects but he is to be congratulated for the logical manner in which he presents it. The bibliography is excellent.



PHYSIOLOGY IN HEALTH AND DISEASE.

By Carl J. Wiggers. *Lea and Febiger, Philadelphia.* \$9.00 net. $9\frac{1}{2} \times 5\frac{3}{4}$; xxvii + 1156; 1934.

This new textbook of physiology compares very well with the best of the standard textbooks. The author departs from the usual form of didactic exposition in order to satisfy more adequately the needs of the medical students. The usual lengthy discussions on biochemistry, for example, have been curtailed and instead primary importance has been given to the interpretation of disease symptoms in terms of observed experimental findings. The subject matter is presented in orthodox order. The chapters on special senses appear much condensed but this is more than compensated for by an exposition of general systematic physiology, ampler and more detailed than is usually found and which is correlated to specific disease conditions. In particular the sections on Heart and Circulation and on Metabolism and Nutrition deserve special mention. The bibliography is extensive and up to date. There are numerous original charts, graphs and figures which together with

the written summaries should enable the student to appreciate intelligently the matter discussed. The author is to be congratulated for he has well achieved his end.



GOOD SAVOURIES.

By Ambrose Heath. *Faber and Faber, London.* 2s. 6d. net. $7\frac{1}{2} \times 4\frac{1}{2}$; 96; 1934.

England's contributions to the world's gastronomic wisdom are neither numerous nor particularly famed. But the notion of a savoury at the end of a dinner was undeniably a smart one, though perhaps not of world-shattering significance. Low cynics of Gallic extraction have even suggested that the real mission of a savoury is, by virtue of its marked and spicy flavor, to overwhelm and nullify any lingering residual taste of a bad dinner. From any such subversive doctrine we formally disassociate ourselves. Savouries are good, both in respect of their basic philosophy and their practical effects upon the taste buds; and this little book tells how to make a lot of very good ones. It explores the whole range of possibilities, hot and cold, fish, flesh, fowl, and "various assorted." We recommend it unreservedly, and particularly to American gastronomisticians, for while it is not a custom with us to end a meal with a savoury it is a widespread habit of our perversity to serve precisely these same dishes with our cocktails *before* we set to at serious eating. The book has a detailed classified index.



AMEBIASIS AND AMEBIC DYSENTERY.

By Charles F. Craig. *Charles C. Thomas, Springfield, Ill.* \$5.00. $10 \times 6\frac{3}{8}$; vii + 315; 1934.

Prepared in answer to the demands of physicians who since the Chicago outbreak of amebiasis in 1933 have felt the need of more knowledge of amebic infection, this monograph surveys all aspects of the subject. On the very first page Dr. Craig emphasizes the fact that the use of the term "amebic dysentery" has been

unfortunate, tending to conceal the less violent results of infection with *Endamoeba histolytica*. The result has been that all too often amebiasis has not been diagnosed properly and promptly.

This is a very comprehensive work covering the etiology, epidemiology, pathology, symptomatology, complications and sequelae, diagnosis, and treatment of the two diseases, amebiasis and amebic dysentery. The literature references are very numerous and given with each chapter, besides which there is an author index as well as a subject index.



HANDBUCH DER BIOLOGISCHEN ARBEITSMETHODEN. *Lieferung 433*. Containing following articles: *Die Methoden der Fluoreszenzmikroskopie*, by Max Haitinger; *Elektrokapillarität*, by Marie Wreschner.

Urban und Schwarzenberg, Berlin. 5.60 marks. 10 x 7; 93 + 1 plate; 1934 (paper).

In the first article two methods for the study of animal and plant preparations under the fluorescence microscope are recommended; direct observation of fluorescence, and observation of microscopic preparations previously treated with solutions of fluorescent substances, the latter method being analogous to the usual histological staining techniques, and differing from them in that the preparation is irradiated with ultraviolet light and the light of the visual range is emitted from certain structures. This method is said to require very little time.

The second paper is a thorough discussion of electro-capillarity and its use in the measurement of electric currents as small as 10^{-8} to 10^{-9} volts such as are encountered in the measurement of nerve and muscle action currents. Various types of electrometers are described and explicit instructions are given for their construction and operation, and for the interpretation of results obtained by their use in physiological experiments.



AUDITORY ACUITY OF MONKEYS. *Comparative Psychology Monographs*, Vol. 10, No. 3, Serial No. 49.

By G. R. Wendt. *The Johns Hopkins Press, Baltimore*. 75 cents. 10 x 6 $\frac{1}{8}$; 51; 1934 (paper).

This is a report on an investigation of the auditory acuity of 11 monkeys. The method, apparatus and training of the animals are described in detail and it appears that the experiments have been conducted with due care and thoroughness. The author observes striking similarity between his results and those obtained on chimpanzees by Elder. Comparing the auditory acuity of the monkeys and of 5 young adults tested with the same apparatus it is to be seen that there is very little difference except for the response to 4096 d.v. For this frequency the monkeys show marked impairment. It may be added that this 4096 "dip" has also been observed in humans and is typical in males between 30 and 50 years of age.



THE PHYSICAL AND MENTAL GROWTH OF PREMATURELY BORN CHILDREN.

By Julius H. Hess, George J. Mohr, and Phyllis F. Bartelme. *The University of Chicago Press, Chicago*. \$5.00. 9 x 6; xxiii + 449; 1934.

The clinical data collected on some 1900 premature infants are summarized and analysed in this monograph. The senior author, noted in the field of pediatrics, describes in some detail methods, nursing care, and apparatus used in his clinic and discusses the causes of prematurity as well as the mortality in this group, presenting some very interesting statistics. The junior authors report on the development of the surviving infants which they compare with that of the normal siblings. It is found, for example, that there is very little difference between the two groups with respect to mental development and susceptibility to childhood infections. On the other hand it appears that increase of height and weight is a function of weight at birth.

The many other observations regarding specific clinical problems together with those mentioned render this book invaluable for physicians, psychologists, anthropologists, etc.

CLINICAL, PATHOGENETIC AND EXPERIMENTAL INVESTIGATIONS OF ENDOMETRIOSIS, Especially Regarding the Localisation in the Abdominal Wall (Laparotomy Scars) with a Contribution to the Study of Experimental Transplantation of Endometrium.

By Hans F. Harbitz. P. A. Nordstedt & Söner, Stockholm. 10 Swedish crowns.

9 $\frac{1}{2}$ x 5 $\frac{1}{2}$; xi + 400; 1934 (paper).

This is a comprehensive monograph on the clinical and experimental aspects of transplanted uterine mucosal membrane growing in the abdominal cavity or in incision scars following abdominal operations. Part 1 deals with ectopic endometrium and the theories that attempt to explain how it reached the site of its development: the "embryological rest" theory, the tubal regurgitation theory of Sampson, and others. Part 2 deals with the accidentally seeded bits of endometrium along the track of the surgeon's knife, as for example at Caesarean sections. Part 3 is experimental, the rabbit serving as subject in intentional transplants of the endometrium and the study of their fate. The literature of Part 2 is the only portion of the extensive literature which the author considers relatively complete. The book is illustrated.



LA SENSIBILITÉ RÉFLEXOGÈNE DES VAISSEAUX AUX EXCITANTS CHIMIQUES. *Actualités Scientifiques et Industrielles* 180. *Exposés de Biologie Générale en rapport avec la Cytologie* III.

By C. Heymans and J. J. Bouckaert. Hermann et Cie, Paris. 9 francs. 10 x 6 $\frac{1}{2}$; 33; 1934 (paper).

It has long been known that the pressure and chemical composition of the blood affect the respiratory, vasomotor and cardio-regulatory centers but it has not been so clear whether the influence is direct or reflex. As a result of their many ingenious experiments the authors conclude that within physiological limits the centers are not directly affected, but that the cardio-aortic and sino-carotid vasosensory zones are the starting-point of respiratory, vasomotor and cardiac reflexes. In the sino-carotid region the

sensitivity to pressure is localized in the vascular wall of the carotid bifurcation, while sensitivity to chemical excitants seems to be situated in the glomus caroticum.



ENDOGENE FAKTOREN IN DER TUMOR-GENESE und der heutige Stand der Versuche einer biologischen Therapie.

By G. Fichera. Julius Springer, Berlin.

7.50 marks. 10 x 6 $\frac{1}{2}$; 83; 1934 (paper).

This is a summary, translated from the Italian, of the work of members and students of the Victor Emmanuel III National Institute for the Study and Cure of Cancer, of which the author is director. It is based on the possibility of utilizing extracts of various organs, particularly the spleen, lymph glands and bone marrow, in the treatment of malignant tumors, either alone or in conjunction with irradiation and surgical procedures. Both experimental and clinical data are presented. There are two bibliographies—one confined to publications by members of the Institute, and the other to the works of others published between 1911 and 1933.



PHYSIOPATHOLOGIE DES TRAVERSÉES CHIMIQUES ET BACTÉRIENNES DANS L'ORGANISME.

By Noël Fiessinger. Masson et Cie, Paris.

45 francs. 9 x 6; 370; 1934 (paper).

This is a series of lectures delivered to medical students on the penetration of foreign substances into the human body and the physiological and pathological reactions involved. The clinical significance of a number of kinds of disorders due to deficient or excessive penetration of materials is fully discussed and there are notes on the appropriate therapeutic treatment. The author apparently believes in extracting the maximum of inferences from the minimum of data and in his interpretations he has been greatly influenced by very recent French work. The work is equipped with a list of authors, but no further bibliographical references.

KREBS im Lichte biologischer und vergleichend anatomischer Forschung. II. Band, 1. Heft: Albuminoide, Schilddrüse, Kropf, Hypophyse, Eierstock, Adenosis.

By Josef Latschneider. Franz Deuticke, Leipzig and Vienna. 5 marks (Germany); 7.50 schilling (Austria). $7\frac{3}{4} \times 5\frac{1}{2}$; 94; 1934 (paper).

The second number of a series of books intended by the author to revolutionize the current concepts of the etiology of cancer. He approaches the problem from the point of view of the normal behavior, organization and productive behavior of the organs involved—in this case, the glands of inner secretions. The conclusions are derived not from original methods and work of his own but by giving different interpretations to the histological preparations of other investigators. The work is illustrated, indexed and provided with a bibliography. We doubt that the author's hopes will be realized on the basis of this book.



AN INTRODUCTION TO HUMAN PHYSIOLOGY.

By Lathan A. Crandall. W. B. Saunders Co., Philadelphia. \$2.00 net. $7\frac{1}{2} \times 5\frac{1}{2}$; 325; 1934.

A text on organ and system physiology which should prove valuable to those individuals interested in getting an accurate and moderately comprehensive survey, in some 300 pages, of the workings of the human body. The book is well written and the subject matter seems to have been competently combed so as to include the more important facts and to exclude more detailed data. The material is organized along conventional lines with the various systems taken up by chapters.



THE SPAN OF LIFE as Influenced by the Heart, the Kidneys and the Blood Vessels.

By Franklin R. Nuzum. Charles C Thomas, Springfield, Ill. \$2.00. $9\frac{1}{2} \times 6$; ix + 108; 1934.

This book is a summary of lectures given before a lay audience with the purpose of describing the functions of the heart, blood vessels and kidneys, showing how

and why the structures of these tissues change, and how such changes may be prevented or treated. It is a very clear, understandable, and generally excellent exposition with several fine diagrams. There is a brief index.



A COLLEGE TEXTBOOK OF HYGIENE. Revised Edition.

By Dean F. Smiley and Adrian G. Gould. The Macmillan Co., New York. \$2.00. $8\frac{3}{4} \times 5\frac{1}{2}$; xvii + 383; 1934.

COMMUNITY HYGIENE. Revised Edition.

By Dean F. Smiley and Adrian G. Gould. The Macmillan Co., New York. \$2.00.

The earlier editions of these two textbooks were reviewed in Volume 3, page 590 and Volume 4, page 573, respectively. In general, the style, point of view, and topics considered are the same in the two editions, but both books have been quite completely rewritten incorporating new contributions to knowledge. To be recommended as excellent texts.



POULTRY AILMENTS for Poultry-keepers, Veterinary, Agricultural and Poultry Students.

By W. P. Blount. Poultry World, London. 5 shillings net. $7\frac{1}{4} \times 4\frac{1}{2}$; x + 306; no date.

This book, designed for the lay reader as well as veterinary, agricultural and poultry students, contains a minimum of technical language. The author, through his wide experience in poultry research and veterinary laboratories in England, has been able to produce an excellent handy volume for poultry keepers. The work is well illustrated and contains a glossary and index.



VITA PIÙ SANA E PIÙ LUNGA. Libro d'igiene dedicato alle persone colte.

By Emilio J. Pampana. Edizioni "Annali d'Igiene," Rome. 12 lire. $8\frac{1}{2} \times 5\frac{1}{2}$; 114; 1934 (paper).

This booklet rationally advises the layman in matters of personal hygiene, diet, etc.

It is well written and at no time does the author become pedantic or transcend well established physiological facts.



PROBLÈMES DE L'HYGIÈNE ALIMENTAIRE. *Actualités Scientifiques et Industrielles* 186.

By J. A. de Loureiro. Hermann et Cie, Paris. 8 francs. 10 x 6½; 28; 1934 (paper).

This little book gives an excellent summary of our present knowledge of nutrition. There is a bibliography of four pages.



BIOCHEMISTRY

AN INTRODUCTION TO PLANT BIOCHEMISTRY.

By Catherine C. Steele. G. Bell and Sons, London. 15 shillings net. 8½ x 5½; viii + 356; 1934.

The purpose of this book is to "provide students of Botany with an introductory account of the chemical nature and relationships of the substances elaborated by plants," and this is accomplished in a very satisfactory manner. Biochemically important substances are arranged and discussed according to their chemical composition, and toward the back of the book are seven chapters on "Plant Metabolism," dealing more specifically with chemical physiology, particularly with enzymes, nitrogen metabolism, and respiration. In the text at appropriate places are directions for laboratory experiments, many of them of a quantitative nature. The book is written for botany students with a little background in organic chemistry, and is well suited to their needs. The bibliographies are short and are limited, for the most part to reference books, and there are two excellent indexes, one for botanical names, and another general index.



LES CAROTÉNOIDES DES PLANTES. *Actualités Scientifiques et Industrielles* 137. *Exposés de Chimie Biologique*. I.

By Edgar Lederer. Hermann et Cie, Paris. 18 francs. 10 x 6½; 83; 1934 (paper).

This is an excellent review of work on the chemical constitution and properties of carotin and related compounds. Although their chemical status has been fairly well defined by important work done since about 1928 the biological rôle of these important substances is still a matter of conjecture. It has been assumed by all workers in the field that carotin plays some part in photosynthesis and it is known that mammals can transform carotin into vitamin A but the exact mechanisms of these processes are still unknown. The reviewer has done this work very capably and this booklet belongs in every biological and biochemical library. There is a bibliography of 200 titles and an index.



CAROTINOIDE. *Ein biochemischer Bericht über pflanzliche und tierische Polyenfarbstoffe*.

By L. Zechmeister. Julius Springer, Berlin. 28 marks (paper); 29.40 marks (cloth). 8½ x 5½; xii + 338; 1934.

In this monograph is recorded the present day chemical knowledge concerning the carotinoids. It gives a detailed account of the structure of the individual forms, their distribution and physiological rôle in plants and animals, their relation to terpenes, sterines, vitamin A, lipoids and albumin, and methods of their determination. This is an important book, written by an authority who has himself contributed much to the sensational progress during the last decade in this field of organic chemistry. The bibliography appears to be complete and the index is adequate.



THE CARBOHYDRATES. *Fifth Edition*.

By E. F. and K. F. Armstrong. Longmans, Green and Co., New York. \$6.50. 9½ x 6; vii + 252; 1934.

This is the fifth edition of a standard biochemical reference book which has been completely rewritten since its last appearance. In the meantime the section on the glycosides has been split off and issued as a separate volume. The authors regard Haworth's formulae for the two

ring forms of glucose as firmly established and the formulae for di- and polysaccharides have been modified accordingly. The book is written for biochemists and biologists rather than for organic chemists. There is a good index and brief bibliographies are appended to each chapter.



ANALYSE DES MÉCANISMES CHIMIQUES CHEZ LES ÊTRES VIVANTS. *Actualités Scientifiques et Industrielles* 165.

By Théophile Cahn. Hermann et Cie, Paris. 8 francs. 10 x 6½; 26; 1934 (paper).

This essay deals tediously and verbosely with some of the more self-evident principles of chemical physiology, especially the precautions necessary in interpreting the results of chemical analyses. Cahn's principal concern is with co-ferments and the only conclusion he reaches that seems to be at all new is that the study of co-ferments will "indicate the nature and importance of the different chains of reactions in tissues."



VITAMINE UND BLUT. *Ein Beitrag zur klinischen Bedeutung der Retikulocyten.*

By Richard Seyderhelm and Hermann Grebe. Johann Ambrosius Barth, Leipzig. 2.70 marks. 9 x 6; 42; 1935 (paper).

The authors claim to have discovered a relationship between vitamins and reticulocytes in the blood and bone marrow. After an introduction on the general clinical significance of increase of reticulocytes, the authors describe experiments showing that following the intake of certain vitamins, particularly B₂, C and D, the number of reticulocytes increased. Both commercial preparations and vitamin-rich foods were used.



HANDBOOK OF CHEMISTRY. *A Reference Volume for All Requiring Ready Access to Chemical and Physical Data Used in Laboratory Work and Manufacturing.*

Compiled and Edited by Norbert A. Lange,

assisted by Gordon M. Forker, with An Appendix of Mathematical Tables and Formulas by Richard S. Burington. Handbook Publishers, Sandusky, Ohio. \$6.00. 7½ x 5½; xiv + 1545; 1934.

This is one of the most useful compendia of chemical, physical, and mathematical data available at present. Its compiler, Professor Lange, has had long experience in preparing handbooks of this sort, and this volume includes an unusual variety of tables, including more data on biochemistry than most books of this kind. The book is very attractively printed in type that resembles the lettering of a draughtsman and that adds greatly to the legibility of the tables.



DIE HORMONFORSCHUNG UND IHRE METHODEN.

By Max Reiss. Urban und Schwarzenberg, Berlin. 15 marks. 8½ x 6; xii + 415; 1934 (paper).

Reiss brings together here the present knowledge concerning the physiology, chemistry, and pharmacology of the hormones, together with methods for their extraction and study employed by various investigators. Several chapters on insulin are included. Each section is supplied with a bibliography and the book is indexed.



FORTSCHRITTE DER PHYSIOLOGISCHEN CHEMIE 1929-1934.

By various authors. Verlag Chemie, Berlin. 4.40 marks. 9 x 6; 311 + 1 folding table; 1934 (paper).

Nineteen authorities in their respective specialties contribute chapters to this survey of the advances in physiological chemistry during the past six years. The book is divided into four sections: natural elements, enzymes, vitamins and hormones. Each chapter is well documented. There is no index.



DIE DREIKOHLENSTOFF-ZUCKER UND IHRE BIOLOGISCHE BEDEUTUNG. *Sammlung chem-*

ischer und chemisch-technischer Vorträge Neue Folge Heft 23.

By Herbert Appel. Ferdinand Enke, Stuttgart. 3.20 marks. $9\frac{1}{2} \times 6\frac{1}{2}$; 40; 1934 (paper).

The essentials of the chemistry of the triosens and their compounds, alcoholic fermentation, and glycolysis, presented in a handy form for the use of biologists.



BIOCHEMICAL AND ALLIED RESEARCH IN INDIA IN 1933.

Society of Biological Chemists, Indian Institute of Science, Bangalore. Subscription Rs. 2 per year. $8\frac{1}{2} \times 5\frac{1}{2}$; 81; 1934 (paper).



SEX

WOMAN as a Sexual Criminal.

By Erich Wulffen. Translated into English by David Berger. American Ethnological Press, New York. \$6.00. $9\frac{1}{2} \times 6$; 528 + 7 plates; 1934.

A more accurate title for this book would be "Women in Court" for the individual case histories are taken almost exclusively from police records, and because Wulffen has used an odd sort of definition of sexual crimes.

Most of woman's criminal tendencies, on account of close-lying psycho-physiological causes, stand in some fixed relation to her sex life. In this sense then the female thief, swindler, extortioner, incendiary, robber, murderer, may be regarded as a sexual criminal. This imputation is so lucid and so easy to understand that its adoption bids fair to become current.

Wulffen is a misogynist, full of bilious generalizations.

"The normal human predisposition induces man to crime." "The instinct of cruelty, typified in the animal, is more easily and severely aroused in woman because she is more intimately tied-up with nature than man, because her organization is more primitive and because her instincts have a freer play." "Just as she lacks a strictly objective sense for justice and truth, so she is also deficient in observing the law which she breaks in opposition to the supreme power and to the police; nor has she a marked sense for the rights of property. This is evinced by the innumerable shop and store thefts, perpetrated almost exclusively by women old and young."

The author has a confidence we do not share in his ability to decide just what actions are instinctive, or due to predisposition. The unkindest thing that can be said about the book, however, is that Wulffen conspicuously failed to heed his own admonition (p. 72). "It must be repeated that our own 'male' experience of sex may perhaps impute to woman traits which she does not possess. In view of the fact that modern thought has increasingly encouraged our doubts in the objectivity of knowledge it would not be amiss to approach our problem with great caution."



RHYTHM OF LIFE. A Guide to Sexual Harmony for Women.

By Sofie Lazarsfeld. Translated by Karsten and E. Pelham Stapelfeldt. Greenberg, New York. \$5.00. $8 \times 5\frac{1}{2}$; xv + 329 + 12 plates; 1934.

In the Introduction the author tells us why the book is necessary: There are man-made books on the subject of the sex life that give man's condescending viewpoints without much bother about that of woman; and there are women authors who write with a touch of bitterness against man in "an over-compensation which is the result of the enforced second-rate state of womanhood." Throughout the work are many astute analyses of the human male from the standpoint of the school of Alfred Adler, founder of the Vienna bureau for advice on the problems of life (including marriage, of course). It is from this "school in the art of living" that the author gets much of her raw material, case histories. Hence the book is greatly colored by the Adlerian philosophy of the inferiority complex. While the book seems much padded, it reads fluently and is punctuated with sound advice based on wide and keen insight into human nature.



NATURE'S WAY. The Fertile and Sterile Periods of Marriage.

By Victor C. Pedersen. G. P. Putnam's

Sons, New York. \$1.00. 7 x 4½; ix + 81; 1934.

In the author's foreword to this little book we read the following: "This book is dedicated to those men and women who regard parentage as the noblest purpose of life, but who further regard the spacing of children as of immeasurable importance." It "will appeal to those men and women who honor nature's laws and refuse the unseemly practices of artificial means." Considerable information is given about the physiology of women and particularly of the monthly cycle and the works of Knaus and Ogino on the days in the month of probable conception and sterility. The author seems very sure of the value of his method for birth control, but in the concluding chapter he states that it is not proved beyond all doubt—only beyond all reasonable doubt. A lengthy literature list is given but the volume is without index.



MARRIAGE HYGIENE, Volume I, Number 1.
Edited by A. P. Pillay. The Times of India Press, Bombay. 18 s. or 10 Rs. per volume of 4 numbers; 4 s. 6 d. or 2/8 Rs., single copy. 9½ x 6; iv + 111; 1934.

A new journal published in India is hereby launched. The aims of the magazine as expressed by the editors are:

1. To secure for the science of conjugal hygiene a proper place in preventive medicine by persistently setting forth the importance of this subject and its interactions on the personal, domestic, and social life and happiness of nations.

2. To publish contributions which are believed to be necessary for scientific sane sex teaching, with an outlook on physiology rather than on pathology, on normal functions of life rather than on the abnormal.

3. To bind its readers together into a brotherhood of clean thinkers and bold fighters against prejudice, evasion, and meaningless taboos.



HOMOSEXUALISMO CREADOR.

By Nin Frias. Javier Morata, Madrid. 25 pesetas. 9½ x 6½; 383 + 12 plates; 1933 (paper).

This is a glowing apology for homosexuality which the author seems to regard as the real essence and cause of

greatness in art, philosophy, and even civil and military leadership. There is practically no famous historical figure which he does not classify as homosexual, either openly or by innuendo. This is possible by using the term homosexuality to cover any form of friendship between men. The purpose of the book is to demonstrate that since all the great men mentioned were homosexually inclined (*sic*), society would gain immensely by tolerating homosexuality. There is no apparent order in the exposition of the material, nor proof of many assertions or of the conclusions. In general, it reads like a mediocre history of art for college students.



BIRTH CONTROL. Its Use and Misuse.

By Dorothy D. Bromley. Harper and Bros., New York. \$2.50. 7½ x 5; xxii + 304; 1934.

Amid the flood of pompous and lurid sex books of the day comes this unsensational volume by Mrs. Bromley—accurate, informative, easily understood. The author, herself a layman, has digested the scientific literature bearing on the subject which she summarizes fairly and without bias. She has, moreover, had the best personal advice in the preparation of the volume.

The book is more than the usual rule-of-thumb catalogue of methods and brands. A background is first laid of a discussion of the medical and sociological justification of, and demand for contraception. Furthermore, each method whether surgical, biological, chemical or mechanical, is discussed in relation to ascertained facts that form the theoretical basis for a given method. Authorities are amply cited.



THE RIGHT USE OF SEX for Best Health and Happiness in Marriage.

Emerson Books, New York. 10 cents. 9 x 6; 4; 1934 (paper).

This leaflet of four pages (two leaves) is by all odds the best thing that we have seen to put in the hands of your children when they are getting ready to be married,

and have become fully conscious that sex presents a personal problem to them. It is fine, and clean, and sound, and its brevity leaves no room for drivel. It is anonymously produced, but we can assure our readers that one of those responsible for its preparation is a wise and distinguished professional zoologist.



SEX-HYGIENE. *What to Teach and How to Teach It.*

By Alfred Worcester. Charles C Thomas, Springfield, Ill. \$2.50. 9 x 6; ix + 134; 1934.

The author has had wide experience in lecturing on sex hygiene before medical groups, students, etc. and in this book he presents a useful guide for physicians, teachers, clergymen, and parents in dealing with problems of sexuality. The volume is indexed.



MARRIAGE AND SEXUAL HARMONY.

By Oliver M. Butterfield. Emerson Books, New York. 50 cents. 8½ x 5½; 40; 1934 (paper).

Another of the ever-increasing instruction books on the sex technique. This small volume has in condensed form about all the information usually presented in larger works on the same subject. Its inexpensiveness should help to increase its popularity.



BIOMETRY

DAS WACHSTUM DER KÖRPERLÄNGE DES MENSCHEN. *Kungl. Svenska Vetenskapsakademiens Handlingar, Tredje Serien, Band 14, No. 1.*

By Gaston Backman. Almqvist and Wiksells, Stockholm. Swed. cr. 7. 11 x 7½; 145; 1934 (paper).

The author presents an interesting if not entirely original method of analysing growth curves of height. Assuming that the curve is a compound one he divides it into three component curves, each of which he fits by a logarithmic function. The three component curves are supposed

to represent the impetus to grow in height that the organism receives respectively at the primordial cell stage, in infancy and at puberty. The variable used in the calculation is the ratio between the heights in two successive years. And here are included 35 sets of calculated ratios resulting from different types of growth curves. These have been applied to 209 series of height measurements collected from the literature, and both theoretical and observed values are reported. The author discusses the different form of growth in well-to-do and poor, dwarfs and giants, in relation to which of the component curves it affects, and also the effect on the latter of the change in function of the endocrine glands. While this represents an important contribution it must not be forgotten that curve fitting is always an empirical process and that other forms of statistical analysis may well give the same agreement between theoretical and observed values.



THE PRINCIPLES OF LOGIC. *An Introductory Survey.*

By C. A. Mace. Longmans, Green and Co., New York. \$4.50. 8½ x 5½; xiii + 388; 1933.

This excellent textbook is intended to provide for the student who is not specializing in logic "a rapid survey of the subject, to indicate some of the points of view from which it may be studied, to outline what is fairly stable in its systematic doctrine and to introduce its problems." It contains an outline of the traditional Aristotelian logic, an introduction to "symbolic" logic—a term which the author considers unfortunate—the development of the theory of classification into the theory of statistics and probability, and a treatment of inductive inference and scientific method. Annotated bibliographies are given at the end of each chapter. There is an index.



STATISTICAL METHODS FOR RESEARCH WORKERS. *Fifth Edition—Revised and Enlarged.*

By R. A. Fisher. Oliver and Boyd,

Edinburgh. 15 shillings net. $8\frac{1}{2} \times 5\frac{1}{2}$; xiii + 319 + 6 folding tables; 1934.

In the fifth edition of this well known textbook, earlier editions of which have been noted in Vol. 1, page 309, and Vol. 8, pages 238-239, the section on the analysis of covariance has been further enlarged and sections have been added on Yates' correction for continuity in the distribution of χ^2 , the exact test of significance for 2×2 tables, and the adjustments to be made in a regression equation when it is decided to omit one or more of the variates. A bibliography and an index are provided.



MASS UND ZAHL IM ZELLEBEN.

By K. A. Heisberg. *Levin und Munksgaard, Copenhagen.* Dan. Kr. 2. 9×6 ; 32; 1934 (paper).

A morphological study of the differences in cell size, number and quality in several organs and tissues under normal and abnormal conditions. The sections of the book deal with: the hypophysis during pregnancy; the suprarenal gland as affected by tumor of the kidneys; the pancreas of diabetics; erythroblasts; lymphocytes during leukemia, mycosis fungoides and other disorders. Some of the dimensional findings are tabulated.



THÉORIE ANALYTIQUE DES ASSOCIATIONS BIOLOGIQUES. *Première Partie: Principes. Actualités Scientifiques et Industrielles 187. Exposés de Biométrie et de Statistique Biologique IV.*

By Alfred J. Lotka. *Hermann et Cie, Paris.* 14 francs. $10 \times 6\frac{1}{2}$; 45; 1934.

In this book Dr. Lotka presents to the French reader some of the concepts and results—such as evolution as the development of a system of interacting species rather than of a single species and the functional equations which describe this development—which are already familiar to English and American readers from his well known *Elements of Physical Biology*.



ZUR BERECHNUNG DES STATISTISCHEN MITTLEREN FEHLERS (STANDARD ERROR). *For-*

meln und Tabellen, Welche die Bestimmung des in der Wahrscheinlichkeitsrechnung angewandten mittleren Fehlers Erleichtern. Acta Societatis Medicorum Fennica "Duodecim," Ser. B., Tom. XIX, Fasc. 2.

By A. M. Ritala. *Universitäts-Frauenklinik in Helsinki, Helsingfors.* $9\frac{3}{4} \times 6\frac{1}{2}$; 85; 1933 (paper).

Tables of $\sqrt{\frac{pq}{n}}$, of $\sqrt{e^2(p_1) + e^2(p_2)}$ and

of $\frac{1}{\sqrt{n}}$ for use in calculating standard errors.



PSYCHOLOGY AND BEHAVIOR

INFANT BEHAVIOR. *Its Genesis and Growth.*

By Arnold Gesell and Helen Thompson, assisted by Catherine S. Amatruda. *McGraw-Hill Book Co., New York.* \$3.00. $9 \times 5\frac{3}{4}$; viii + 343; 1934.

A study of developmental behavior in infants under one year by a well-known investigator of child psychology. Chapter three (pp. 44-267) constitutes the main part of the book, and summarizes the observed behavior patterns shown in 25 different situations, for 15 different age levels from 4-56 weeks. Some of the behavior characteristics studied related to posture and locomotion, but for the most part the authors concerned themselves with observations on prehension and manipulation behavior—(i.e. dangling ring behavior, rattle behavior, single and massed cubes behavior, tower building behavior, pellet behavior, bell behavior, ring and string behavior, etc.). Chapter four deals with the ontogenetic patterning of infant behavior. For purposes of clarity the authors divide the developmental periods into three prenatal periods and six postnatal periods which carry the child from time of conception up to its first birthday. They then consider four distinguishable spheres of behavior: (1) posture and locomotion, (2) prehension and manipulation, (3) perceptual and adaptive behavior, (4) social and language behavior, and relate them in so far as is possible to the nine various age levels. For purposes of orientation this chapter should be read first. Chapter five deals

with the rôle of maturation in the patterning of behavior, and chapter six with the possibilities and limitation of developmental diagnosis of infant behavior. Except for minutiae of the tables and the rather long and complicated account of behavior items, this book is extremely enjoyable and profitable reading, besides being a thoroughly sound and scholarly work.



INDIVIDUAL PSYCHOLOGY AND SEXUAL DIFFICULTIES (II).

By Alfred Adler and F. G. Crookshank.
The C. W. Daniel Co., London. 2s. 6d.
net. 8½ x 5½; 55; 1934 (paper).

The Medical Society of Individual Psychology (abbreviated to I.P.) is a British organization that, collectively, follows as a disciple the leadership of Dr. Alfred Adler. Its biological philosophy is perhaps fairly indicated in the following quotation from a lecture by Dr. Adler, with which the present volume opens.

Left-handedness is inherited, but the results are the results of *us*. Therefore consider what I always say: Inherited abilities and disabilities, environmental influences are only the *bricks*. You cannot know what this child will build up. You can influence the child, but the child is free in the use of these bricks and therefore you cannot predict, but you can see what the child produces, how he uses his inheritance and his environmental influences. At this point I want to say something about the accusation made by critics and revilers of I.P.—that I.P. overlooks inheritance. That is ridiculous, because I started with inheritance, but I regard it in the right place, as the bricks. Others say that I.P. is a teaching of environment. That is also ridiculous, because it omits what is the most important part of I.P., how the child uses these bricks. The answer is that you find children with great deficiencies who develop well, and others with little deficiencies who develop badly. You find millions of varieties. Talking of the deficiency does not give you any hint what the child will do.

The society issues pamphlets in a regular quarterly series, of which this is one. Besides the general lecture by Dr. Adler from which we have quoted, he contributes another paper on Sexual Perversions. The late and lamented Dr. F. G. Crookshank has a paper on Individual Psychology and Sex. The remainder of the volume is made up of news, notes and announcements.

MENTAL DEFECT.

By Lionel S. Penrose. Farrar and Rinehart, New York. \$2.50. 8½ x 5½; xi + 205; 1934.

An extremely readable exposition of the status of the study of feeble-mindedness. The purpose seems to be not so much the introduction of new data as the synthesis and correlation of existing information on many phases of the subject. The author emphasizes the necessity of interpreting results in the light of the unconscious selection of material. One example of such selection is that the institutionalized feeble-minded will usually come from the lower social classes where the environment may be very unfavorable. Also, the author points out that family pedigrees are practically never published except when some defect is apparently inherited so that we have neither a normal population nor one showing isolated cases of the defect with which to compare. Another variable often not sufficiently considered is the variation in all laboratory tests, including the Wassermann. Penrose's discussion of this point is very good.

Some rather fancy statistics are introduced by the author. Sometimes the reasons for departing from the conventional statistical procedures are not very clear, and far-reaching results are determined from inadequate samples.

The chapter on "Treatment in the United States" added by the American publishers does not come up to Dr. Penrose's own contribution.



THE DIABOLIC ROOT. *A Study of Peyotism, the New Indian Religion, Among the Delawares.*

By Vincenzo Petrullo. University of Pennsylvania Press, Philadelphia. \$2.00. 8½ x 5½; xi + 185; 1934.

Peyote, also known as mescal, *Lophophora Williamsii*, *Echinocactus Williamsii*, and *Anhalonium Lewinii*, is a species of cactus which produces a kind of intoxication sometimes accompanied by visions and color hallucinations. The healing and religious cult developed around its use has spread from the Indians of northern Mexico to a number of tribes in the

United States. This book is a study of the cult as it has developed among the Delawares of Oklahoma. The meetings are held in a tipi with a fire in the center which has been kindled with flint and steel and a crescent shaped altar on which is placed a piece of peyote. The devotees eat peyote to the accompaniment of ritual songs. "Merely eating peyote is not enough. He must inspect his motives, attain the proper state of humility, and sincerely desire to lead a pure life." Among the Delawares of Dewey, who have so far as possible kept up their traditional religious ceremonies, the Peyote cult has been kept in substantially the form in which it was borrowed from other tribes, whereas among the Delawares of Anadarko, who no longer practise the traditional ceremonies, elements of these, as well as certain Christian elements, have been incorporated in the Peyote ritual. The book contains a bibliography of three pages.



THE PROBLEM OF MENTAL DISORDER. A Study Undertaken by the Committee on Psychiatric Investigations, National Research Council.

Members of the Committee: Madison Bentley, Chairman; E. V. Cowdry. McGraw-Hill Book Co., New York. \$4.00. 9 x 5½; x + 388; 1934.

This is an important contribution to the literature on psychiatry. The first part consists of articles by the more noted individual exponents of the several schools of psychotherapy. Thus, C. Macfie Campbell presents the viewpoint of "clinical" psychiatry; A. Meyerson, that of "medical" psychiatry; I. L. Wechsler, that of the neurologist; A. Meyer speaks as a psychobiologist; L. S. Kubie as a psychoanalyst. The different concepts are ably summarized by the editors who note that the "commonest" feature is the influence of medicine, and "the strongest tradition in the facts and theories under scrutiny is that of the physicians treating a disease by accepted means of diagnosis and therapy." The second part consists of papers by specialists in the various disciplines that bear more or less directly on the problem

of mental disorder, from anatomy to education. Some of these papers are better than others but all are worth reading.



TWENTY-FIVE YEARS AFTER. *Sidelights on the Mental Hygiene Movement and Its Founder.*

Edited by Wilbur L. Cross. Doubleday, Doran and Co., Garden City, N. Y. 8 x 5½; xv + 564; 1934.



DE OMNIBUS REBUS ET QUIBUSDEM ALIIS

THE SEARCH FOR TRUTH.

By Eric T. Bell. The Williams & Wilkins Co., Baltimore. \$3.00. 8½ x 5½; x + 279; 1934.

Dr. Bell is a worthy successor of Augustus De Morgan. There are few writers who can make so readable a book out of such technical subjects as logic and scientific method. This is a highly unconventional history of man's efforts to solve the riddles of the world he lives in by means of deductive reasoning. The story begins with the discovery by the Egyptians of the formula for the volume of a pyramid. The next step is the recognition by the Greek geometers of the need for the abstract, deductive proof of their theorems by means of the rules of logic from certain postulates. "Thus it came about that the age of modern science, initiated by Galileo in the Sixteenth Century, inherited at least two Absolutes," the axioms of geometry and the laws of logic. However, in 1826 Lobatchewsky showed that a self-consistent geometry might be built up by altering one of the postulates of geometry and in 1930 Lucasiewicz and Tarski similarly proved that more than one self-consistent system of logic, in which a proposition may be neither true nor false, could be built up. And so our hopes of ever discovering the Truth go glimmering.

By way of interlude Dr. Bell pays his respects to Dean Inge, Jeans, Eddington, Dunne of the *Experiment with Time*, Maeterlinck and other mystical expound-

ers of the fourth dimension, and all testimonial writers, whether for halitosis "cures" or for the reconciliation of science and religion.



BURGUNDY.

By *Stephen Gwynn. Constable and Co., London.* 5 shillings net. 7 $\frac{3}{8}$ x 4 $\frac{7}{8}$; 144; 1934.

This seems to us one of the best volumes that has so far appeared in *Constable's Wine Library*. This is high praise, because its predecessors have set a high standard. But burgundy is perhaps the most difficult group of wines to be thoroughly and soundly wise about. The French have so ordered matters by law that, within the confines of France itself, it is possible without serious risk of insult to palate or stomach to place that naive and abiding trust in labels so characteristic of Americans, as long as the discourse is of *clarets*. But the case is far otherwise as regards *burgundies*. There your taste is your only safe guide. One of the most famous, reliable, and completely honest of burgundishippers in Nuits-St.-Georges told us once that a large percentage of his total product was shipped entirely unlabelled to the most luxurious hotels, restaurants and clubs of Europe, the buyer having the privilege of adorning the bottles with any device that might seem fitting to him and the circumstances, though he had been honestly and completely informed as to the wine's lineage and age. So it will be seen that to set up as a philosophic guide to the ignorant about burgundy demands a thorough and profound educational training and plenty of first-hand research. Mr. Gwynn qualifies nicely in this respect. He has produced a book that entertains as it instructs. We recommend it. Unfortunately it lacks an index.



THE HUMAN GYROSCOPE. *A Consideration of the Gyroscopic Rotation of Earth as Mechanism of the Evolution of Terrestrial Living Forms. Explaining the Phenomenon of Sex: Its Origin and Development and Its Significance in the Evolutionary Process.*

By *Arabella Kenealy. John Bale, Sons and Danielsson, London.* 12s. 6d. net. 8 $\frac{3}{8}$ x 6 $\frac{5}{8}$; iv + 313 + 16 plates; 1934.

In presenting the consideration that, as plastic clay on the rotating disc of little potter's wheel of industry is shapen and moulded in varieties of symmetrical three-dimensional form, increasingly uprising in the vertical, so upon the rotating surface of the great terrestrial potter's wheel of Creative Evolution, the plastic matter of terrestrial organisms has been shapen and moulded in the countless diversities of increasingly complex, structurally differentiated three-dimensional forms of living species, progressively uprising in the vertical in the terms of increasingly complex elevated posture—I have ventured to base my argument upon the Gravitation of great Newton, instead of on the later Einstein theory.

This hefty sentence opens a strange book. Miss Kenealy (who is, by the way, a Dublin L.R.C.P.) is a paradoxer in De Morgan's sense, and her book is a perfect example of how the paradoxer's mind works. One of its chief characteristics is a total inability to differentiate symbolism and analogy from reality. Another is a dreadful prolixity. But withal we are disposed to feel with De Morgan that the world would be a duller place without its paradoxers.



THE CONCISE OXFORD FRENCH DICTIONARY.

Compiled by Abel Chevalley and Marguerite Chevalley. Oxford University Press, New York. \$3.00. 7 $\frac{1}{2}$ x 5; xx + 895 + 5 plates; 1934.

This excellent French-English dictionary has the useful feature of danger signs warning the user of differences in meaning of French and English words of like form, such as *dérider* and "deride." Besides the inclusion of technical terms pertaining to automobiles, airplanes, etc., diagrams of an airplane, an automobile, a motor, steam and sailing ships, photographic apparatus, and architectural forms with the French and English names of the various parts are given.



THE ADVANCE OF SCIENCE.

Edited by Watson Davis. Doubleday, Doran and Co., Garden City, N. Y. \$3.50. 9 x 5 $\frac{7}{8}$; xiv + 400; 1934.

The editor of this book, who is also editor of Science Service, has summarized briefly and for popular consumption scientific discoveries and inventions of the last few years. In some cases he has added the historical background relative to the particular problem. The subjects included cover the whole gamut of science from cosmic rays to Neanderthal man. It is surprisingly free from errors and within its limits really excellent. Complete references would give it greater utility.



ATOMIC STRUCTURE AND SPECTRAL LINES.

By Arnold Sommerfeld. Translated from the Fifth German Edition by Henry L. Brose. E. P. Dutton and Co., New York.

\$10.80. 8½ x 5½; xi + 675; 1934.

This English translation of the latest edition of Professor Sommerfeld's classic text on atomic structure is of undeniable value as text for advanced physics courses

in English speaking universities. The work has undergone a complete revision in order to include the most recent work in spectral analysis. The Rutherford-Bohr atom is still held as a useful model for interpreting the main features of spectroscopic phenomena.



REPORT ON CONFERENCE ON SUPERVISED CORRESPONDENCE STUDY. *To formulate policies regarding its use as a practical means of enriching the curriculum of American Secondary Schools.*

International Textbook Co., Scranton, Pa.
25 cents. 9 x 6; 66; 1934 (paper).

A brief report of the findings of a Conference held among various state educators at Teachers College, Columbia, August 1934. The whole subject is still in such a pioneer state that no important conclusions came out of the conference.



THE QUARTERLY REVIEW *of* BIOLOGY



THE CELLULAR TRANSMISSION OF SUBSTANCES, ESPECIALLY NEUROHUMORS

THE ANNUAL SOMERVILLE LECTURE DELIVERED AT
MCGILL UNIVERSITY NOVEMBER 24, 1933

By G. H. PARKER

Harvard University

IN ACCEPTING the invitation of the Dean and the Faculty of Graduate Studies and Research at McGill University to deliver the Annual Somerville Lecture I wish at the outset to express my keen appreciation of the honor done me and to extend my sincere thanks to the Dean and the Faculty for this opportunity to address you. It is furthermore a great pleasure for me to occupy a lectureship, the present position of which is in large measure due to the efforts of my former associate at the Woods Hole Marine Laboratory, Dr. Arthur Willey, whose leadership in the early days of seaside work meant so much to us all. The seashore is indeed the place of all places where the study of animal life can best be carried on and much of what I shall have to say to you this evening represents work done at the Woods Hole station where Dr. Willey, Dr. Lloyd, and many others from your laboratories have worked.

COLOR CHANGES IN ANIMALS

I have selected for my address the topic neurohumoral transmission, a subject

which is an outgrowth of the general field of animal coloration. I am emboldened to think that this subject might well have interested the founder of this lectureship, Mr. James Somerville, for it is a part of the natural history of animals, a field in which as an educator he was notably active. Animal coloration has had a long history, for it has claimed the attention of investigators from the days of Aristotle and of Pliny. You are doubtless aware that many animals can alter their tints with remarkable rapidity and that in such forms as the African chameleon this ability has come to be truly proverbial. Some creatures, such as the devil fishes and squids, accomplish this transformation by many small systems of radiating muscle fibers whereby minute sacs of colored materials may be expanded or contracted, thus producing that unusual play of colors which characterizes these animals. Other forms, such as the shrimps, prawns, fishes, frogs, toads, and lizards, possess a much simpler device in which individual pigment cells or chromatophores concentrate or disperse their

contained pigment and thus withdraw or spread to view their colors. The resulting changes in the tints of these animals may be said to be due in part to the external and in part to the internal environment. It is in particular to this type of chromatophore that I wish to direct your attention, for the methods involved in its action call for the application of rather novel and remarkable principles that are of no small importance, in my opinion, in the elucidation of many organic relations. In treating this subject I shall limit myself in the main to the conditions of the chromatophores in the vertebrates and particularly in the fishes, but I shall show you, I hope, that the principles thus brought forward apply very broadly and are probably of considerable significance not only for many vital processes in animals but in plants also.

Among the ancients both Seneca and Pliny record the color changes of certain fishes as, for instance, the mullet whose activity in this respect played an important part in the preparations for Roman feasts. Records of this kind occur through later times. In 1819 Sangiovanni first saw clearly the chromatophores of cephalopods. He introduced the word chromatophore, in Italian *cromosforo*, portrayed the movements of these cells, and expressed the belief that they were under the influence of nerves. The chromatophores of lizards were first clearly described by Milne-Edwards in 1834, of frogs by Ascherson in 1840, and of fishes by von Siebold and by Buchholz independently in 1863. Meanwhile in 1830 the adaptive relations of the color changes in fishes to the backgrounds on which they rested had been pointed out by Stark.

In a series of papers published by Pouchet between 1871 and 1878 this distinguished French investigator demonstrated, especially in the flatfishes, the

control of chromatophores by nerves and in particular by the sympathetic nerves (Fig. 1). The actual innervation of chromatophores in fishes was subsequently figured by Ballowitz (1893) who studied this subject by appropriate histological methods (Fig. 2). In 1852 Brücke had presented evidence in favor of nervous influence over the chromatophores in the chameleon. As a result of these and other studies the belief in the nervous control of chromatophores became generally accepted. But the best efforts of many investigators including such workers as Vulpian (1875), Bimmermann (1878), and Biedermann (1892) yielded no conclusive evidence in favor of this opinion as applied to the amphibian chromatophores. Following on Corona and Moroni's discovery in 1898 that the pigment in frog chromatophores is concentrated by adrenalin and Smith's discovery that the removal of the pituitary gland from the tadpole results likewise in a concentration of the pigment in its chromatophores, came a series of papers centering chiefly about the work of Hogben, one of your former associates. In these papers it was shown that the amphibian pigment cells were controlled almost exclusively by pituitary secretions and not by nerves (Figs. 3 and 4). This conclusion was in strong contrast with what had been established for the fishes and with what seemed true for the lizards, for though Redfield had shown in 1916 that a hormone, probably adrenalin, was one of the agents in the concentration of pigment in the chromatophores of *Phrynosoma*, most workers including Redfield himself admitted that nerves were the chief controlling factors for color changes in these animals (Fig. 5). Thus at the beginning of the present decade the majority of investigators in this field would have agreed that the control of vertebrate chromatophores

was by nerves in fishes, by hormones in amphibians, and in the main by nerves in lizards.

These somewhat anomalous conclusions led me to speculate on a possible unifica-

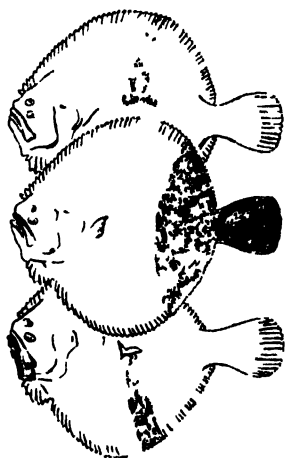


FIG. 1. TURBOTS IN WHICH THE MELANOPHORES HAVE BEEN RENDERED DARK AND INOPERATIVE BY THE CUTTING OF THE CONTROLLING NERVES
Pouchet, 1876

chromatophores they might do so by secreting from their terminals material which, like adrenalin or pituitrin, would bring about a concentration or a dispersion of pigment in these cells. Hence the so-called nervous control and the humoral control of chromatophores might be regarded as essentially the same. In what is assumed to be the nervous control of chromatophores the active substance is produced, according to this interpretation, in very close proximity to the reacting cell, in the humoral control this substance is produced at a distance and is then carried by blood and lymph to the chromatophore. The substances thus involved I have called neurohumors to use a term introduced by Henri Fredericq in 1927, and the idea that chromatophores as well as other effectors, and even neurones themselves, could be thus excited to activity I designated as neurohumoralism. After having worked out this unification

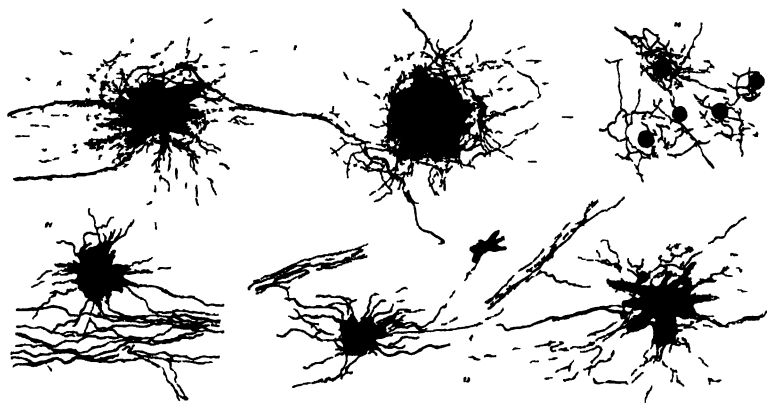


FIG. 2. FISH MELANOPHORES, SOME WITH THEIR PIGMENT DISPERSED, OTHERS WITH IT CONCENTRATED, AND ALL SO STAINED AS TO SHOW INNERVATION
Ballowitz, 1893

tion in this field of work. In a lecture delivered at the University of Cambridge, England, in May, 1930, and subsequently published as a small volume entitled *Humoral Agents in Nervous Activity*, I suggested that where nerves appeared to control

I was interested to find that essentially the same idea as that just detailed had been advanced by Professor Giersberg in 1930 and published by him in a paper on the general color changes in animals. It is gratifying to find that the specula-

tions of so thorough a student of this subject as Professor Giersberg should have led him to this conclusion.

I wish now to present to you work on the color changes in certain fishes which I have done during the last year or so, partly at Woods Hole and partly at Harvard and which not only bears on the question of neurohumors but also opens up further fields of inquiry. I shall speak about the conditions in the dogfish, the catfish, and the killifish.

MECHANISM OF COLOR CHANGES IN THE DOGFISH

The color changes in the common dogfish, *Mustelus canis*, were first studied and



FIG. 3. TWO FROGS OF WHICH THE RIGHT-HAND INDIVIDUAL HAD BEEN INJECTED SIX HOURS PREVIOUSLY WITH PITUITARY EXTRACT AND THE LEFT ONE KEPT LIGHT COLORED AS A CONTROL

Hogben, 1924

described only very recently by Lundstrom and Bard (1932) who found that this fish assumed a light coloration in an illuminated tank with light walls and a dark one in a similar tank with dark walls. These contrasts in color are shown in Figure 6. The various tints of the dogfish's skin according to these investigators depend upon the state of the dermal melanophores. When the pigment granules of these cells are dispersed throughout the bodies of the cells and their processes

(Fig. 7), the fish is dark in tone; when they are concentrated near the center of the cell (Fig. 8), the fish is light in color. It was further shown by Lundstrom and Bard that after the pituitary body was removed from the base of the brain of the dogfish, the animal gradually acquired a pallor which began to appear about 30

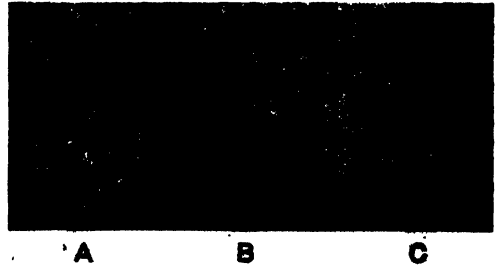


FIG. 4. WEB IN A FROG'S FOOT SHOWING THE MELANOPHORES OF A PIGMENT SPOT IN A DARK CONDITION (A), IN AN INTERMEDIATE ONE (B), AND IN A PALE ONE (C)

Hogben, 1924

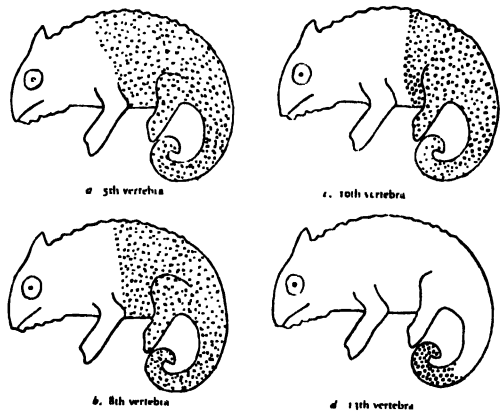


FIG. 5. CHAMELEONS IN WHICH ANTERIOR PALLOR HAD BEEN INDUCED AFTER SEVERANCE OF THE SPINAL CORD IN THE REGION OF THE FIFTH VERTEBRA (A), THE EIGHTH (B), THE TENTH (C), AND THE THIRTEENTH (D)

Hogben and Mirvish, 1928

minutes after the operation and gained a permanent maximum in about 12 hours. This pallor was not apparent when only the anterior lobe of the pituitary body was taken out, but it always appeared after the loss of the neuro-intermediate lobe.

Hence it was concluded that this lobe, which is believed to be the equivalent of the pars intermedia of the pituitary body in the higher animals, is the structure



FIG. 6 TWO DOGFISHES ORIGINALLY OF THE SAME TINT, TWENTY-FOUR HOURS AFTER THE REMOVAL OF THE HYPOPHYSIS FROM THE FISH ON THE RIGHT THEY NOW SHOW EXTREME DIFFERENCES IN TINT
Lundstrom and Bard, 1932



FIG. 7 DERMAL MELANOPHORES OF A DOGFISH SHOWING THEIR PIGMENT IN THAT STATE OF EXTREME DISPERSION WHICH CAUSED THE FISH TO APPEAR DARK

Lundstrom and Bard, 1932

from which emanates the neurohumor concerned with the dispersion of melanophore pigment. This conclusion was confirmed by tests made with fluid extracts

from this lobe. When a seawater extract of the neuro-intermediate lobe was injected into a dogfish made light-colored by hypophysectomy, the fish became temporarily dark. This darkening first appeared in about three minutes after the injection was made, reached a maximum in about an hour and disappeared in from five to six hours. Light fishes similarly prepared were temporarily darkened by injections of commercial pituitrin, infundin, and pitressin but not of pitocin.



FIG. 8 DERMAL MELANOPHORES OF A DOGFISH SHOWING THEIR PIGMENT IN THAT STATE OF EXTREME CONCENRATION WHICH CAUSED THE FISH TO APPEAR LIGHT

Lundstrom and Bard, 1932

Lundstrom and Bard concluded from these various observations that the pituitary gland, and particularly its neuro-intermediate lobe, produces the hormone that dominates the color changes in the normal dogfish. The dark phase of this fish according to them is the result of a large amount of the appropriate pituitary product in the blood of this animal. The light phase is not especially discussed by them but it is to be inferred from their account that it depends upon the relative absence of the pituitary hormone.

This general conclusion, apparently ade-

quate in itself, may not, however, represent the total situation. Nerves so commonly play a large part in the color changes of fishes that it seemed unwise to accept Lundstrom and Bard's account as complete without first testing the possibility of some form of nervous control. For this reason my assistant, Miss Helen Porter, and I resolved on a further investigation of this subject with the following results.

If in a moderately dark dogfish deep cuts transverse to the rays of any fin are made or similar cuts are inflicted on the body, these cuts give rise to light bands or splotches which are clearly visible in the skin for many hours or even days thereafter. If the spinal cord of a dogfish with the adjacent tissue is transected in the posterior part of the body, the portion of the fish behind the cut becomes irregularly slightly lighter. The light bands are best seen when they are produced on the pectoral fins and are most easily induced by making a well circumscribed cut completely through the fin from one face to the other and at right angles to the rays.

In the pectoral fin the course of the main blood-vessels can be easily seen through the translucent substance of that organ and the cut may be made either distal or proximal to the chief vessels, thus leaving the blood supply to the fin essentially undisturbed. The cut necessarily severs a number of the smaller vessels, but, if its position is well chosen, it can be shown to introduce no serious interference with the circulation. After such a cut has been made a light band quickly develops extending from the cut to the free edge of the fin. This band assumes the width of the cut, never more, and always extends over the fin distally from the cut, never proximally. It follows very closely the lines of the fin rays and their associated nerves. Its detailed nature and fate de-

pend upon the light or dark condition of the dogfish in which it is induced.

In a dark dogfish the band is a lightish area of rather irregular outline (Fig. 9). It is seen with certainty in from ten to fifteen minutes after the cut has been made and it reaches its maximum in about a day. After this it gradually fades out, to disappear completely in from two to three days. A narrow band three to four millimeters wide will, however, disappear in a little over a day; one of a centimeter wide will remain visible for as much as two to three days. The light band fades by being replaced by the dark coloration of the surrounding fin area, the center of the band near the periphery of the fin being the last to disappear (Fig. 10).

In a light dogfish the band is more clearly defined in outline than in a dark one. Its edges are sharply marked and they can be traced from the ends of the cut to near the edge of the fin (Fig. 11). Although the fish may be extremely light in color, the band is always still lighter and agrees in tint with the white border of the fin. Unlike the light band on the dark fish, that on the light fish seems never to be obliterated. At least in all light dogfish kept by us in the laboratory tank the light band has persisted as long as the fish has lived, a period of at most about five days. When from a light dogfish with a light band the eyes are removed the fish darkens and the band eventually disappears as it does in an ordinary dark fish in which it had been induced by a cut.

These light bands give indubitable evidence of the participation of nerves in calling forth the light phase of the dogfish's coloration. The light band resulting from a cut follows exactly the course of the severed nerve-fibers. The severance of these fibers, we believe, throws them into full activity by which their effectors, the melanophores, are made to concen-

trate their pigment completely and to remain in this state for a considerable period. This action on the part of the nerve-fibers appears to persist for as much as five days, an unusual length of time,

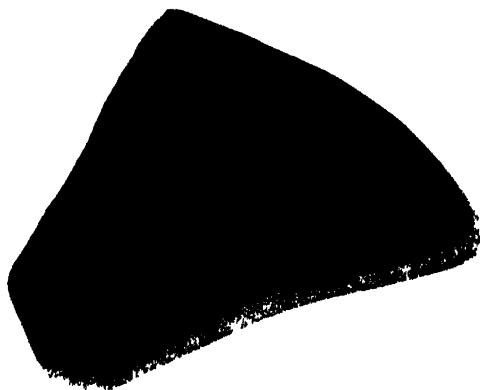


FIG. 9. FIN FROM A DARK DOGFISH SHOWING A LIGHT BAND WHICH RESULTED FROM THE SEVERANCE OF THE FIN RAYS AND THEIR ACCOMPANYING NERVES ABOUT AN HOUR BEFORE THE PREPARATION WAS MADE

Parker and Porter, 1934

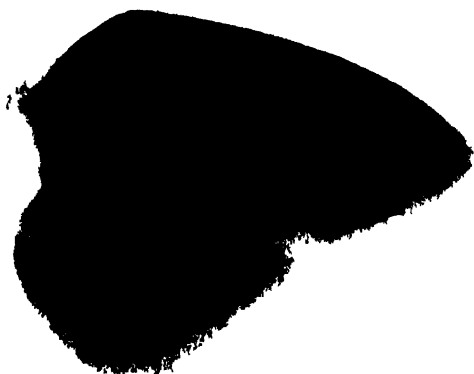


FIG. 10. FIN FROM A DARK DOGFISH SHOWING A LIGHT BAND IN PROCESS OF GRADUAL DISAPPEARANCE THROUGH THE INVASION OF A PITUITARY NEUROHUMOR BY WHICH THE PIGMENT IN THE MELANOPHORES OF THE PROXIMAL PART OF THE BAND WAS DISPERSED

Parker and Porter, 1934

and is overcome only when the dogfish is placed in a dark-walled receptacle. Under these conditions the neurohumor from the pituitary gland enters the blood and as this fluid invades the region of the band

the contained neurohumor in steadily increasing amounts must eventually reach the melanophores. Here it finally overcomes the action of the nerve-fibers that bring about a concentration of melanophore pigment and in the end induces the dark phase of the fish by a dispersion of this pigment. This view of the interaction of the dispersing and concentrating factors in the color changes of this fish is supported by the fact that if blood is drawn from a dark dogfish and injected under the skin of a light one, a dark spot

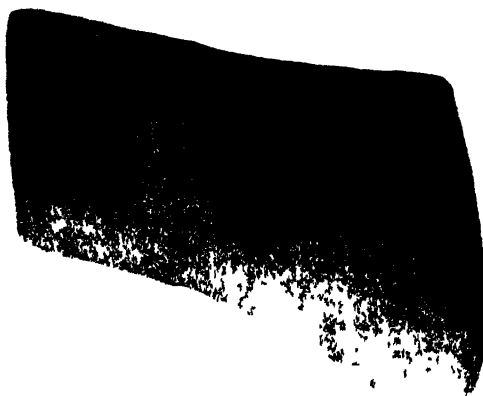


FIG. 11. FIN FROM A LIGHT DOGFISH SHOWING A LIGHT BAND SEVERAL DAYS AFTER THE INDUCING CUT HAD BEEN MADE

Parker and Porter, 1934

quickly appears in the region of the injection and remains there several hours. Blood from a light dogfish, however, has no effect upon the coloration of a dark one and we are therefore led to conclude that there must be a profound difference between the exciting agents of the dark and of the light phases. In the dark phase the pituitary hormone, a dispersing neurohumor, must be soluble in the blood. In the light phase, a state nervously controlled, it is not known with certainty whether there is a neurohumor or not, but if one is involved it must be insoluble in blood. Thus the color changes in the

dogfish appear to be more complex than they were originally supposed to be by Lundstrom and Bard, for in addition to a neurohumoral control of the dark phase by means of a blood-soluble hormone from the neuro-intermediate lobe of the pituitary gland, there is an equally significant nervous control of the light phase, a control that certainly does not involve a blood-soluble neurohumor.

when it is in a similar black walled tank. The extreme differences in these tints are shown in Figure 12. The full change in this fish from light greenish gray to black is slowly accomplished and may require under ordinary circumstances as much as a whole day. The reverse change from black to green-gray is more rapidly carried out and may be completed in about three hours. Catfishes whose eyes have



FIG. 12. LIGHT AND DARK CATFISHES SHOWING THE EXTREMES OF TINT ASSUMED BY THESE FISHES WHEN IN AN ILLUMINATED WHITE-WALLED TANK OR IN A SIMILAR BLACK-WALLED ONE

Parker, 1934

MECHANISM OF COLOR CHANGES IN THE CATFISH

The second fish whose chromatophoral activities I wish to discuss is the common freshwater catfish or hornpout, *Ameiurus*. The color changes in this fish have already been studied from a variety of standpoints by Van Heusen (1917), Bray (1918), Pearson (1930), Odiorne (1933) and Bacq (1933). In color change this fish ranges from a light greenish gray when it is in a white illuminated tank to almost black

when it is in a similar black walled tank. The extreme differences in these tints are shown in Figure 12. The full change in this fish from light greenish gray to black is slowly accomplished and may require under ordinary circumstances as much as a whole day. The reverse change from black to green-gray is more rapidly carried out and may be completed in about three hours. Catfishes whose eyes have

been securely covered so as to have all light excluded from them or fishes from which the eyes have been excised become almost black and remain so indefinitely. The direct means by which catfishes control the tints of their bodies will now be considered.

The tail of the catfish is a firm membranous structure supported by some fifteen or more bony rays. The caudal nerves pass out into the tail on the lines of these rays. If a ray is cut through

completely the nerves associated with it are severed and the pigment concentrated in the melanophores of the area thus denervated soon spreads out and darkens the whole of each cell. In a little over two hours after such an operation the severed ray is the axis of a band almost black in tint that extends from the cut in the fin to the edge of the tail (Fig. 13). If two adjacent rays are cut, a band of double width is produced. If an uncut

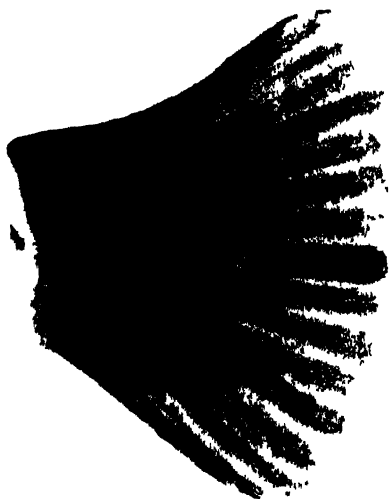


FIG. 13. TAIL OF A CATFISH SHOWING DARK BANDS THAT RESULTED FROM THE TRANSVERSE CUTTING OF RAYS AND DARK TRIANGLES FROM SIMILAR INTERRADIAL CUTS

Parker, 1934

ray intervenes between two cut rays, the uncut ray forms the axis of a light band flanked on each side by a dark one. In such preparations the limits of each band can be seen to be so exactly drawn as to show clearly that the controlling nerve-fibers are very definitely restricted to each band and do not overlap into the adjacent bands. The nerves and their branches in each band have much the form of a feather in which the axis of the feather corresponds to the radial nerves of the fin ray and the side barbs to their lateral branches.

The general distribution of several adjacent sets of radial nerves and their branches is such as would be seen if feathers were placed side by side so that the edge of the vane of one feather was just in contact with that of the next one. It follows from this arrangement that if transverse cuts are made in the catfish's tail not through a ray but through the spaces between rays only a small triangular area will be denervated. In consequence only small black triangles should appear in such preparations. Triangles of this kind can easily be demonstrated (Fig. 13). The dark areas produced by the severance of nerves, be they bands or triangles, are when fully formed as near black as the blackest tint of any catfish and show the action of the nerves concerned with the dispersion of the melanophore pigment to be at its maximum.

If in a catfish of intermediate tint a dark radial band is produced by cutting the nerves of one ray, this band will gradually disappear, in part by slowly fading as a whole and in part by shrinkage of area. The band becomes narrower by loss at its edges. This narrowing occurs especially over the proximal extent of the band and becomes complete here before the distal shrinkage has been accomplished. Hence the last of any such band to be seen is its extreme distal tip. Bands produced by cutting single rays in the catfish have been found to disappear in from two to five days. The steps in this process are well shown in Figure 14 where A represents the fully formed band, B the partly shrunken one, and C the last traces of a band.

When the edge of a newly cut band is examined closely under the microscope (Fig. 15), the melanophores with dispersed pigment and constituting the band itself can be sharply distinguished from those with concentrated pigment and

characteristic of the light-colored general surface of the fish. The line of separation between these two kinds of melanophores is a fairly sharp one. But after the band has begun to disappear and particularly after its shrinkage has well started this sharpness disappears and the edge of the band is no longer clearly marked. It is as though some influence that brought about a concentration of the melanophore

of the dark bands to adrenalin. If a catfish, in which a newly induced caudal band is fully developed, is injected with an appropriate amount of adrenalin, the whole fish within fifteen minutes becomes very light. This change affects not only the general surface of the fish but the band as well. It is remarkable to watch the rapid and complete disappearance of a band of maximum darkness under the influence of adrenalin. Within three

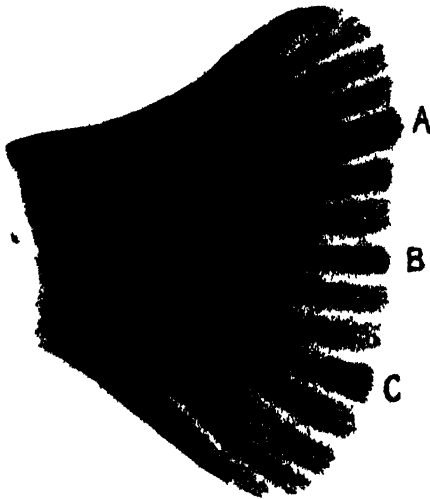


FIG. 14. TAIL OF A CATFISH SHOWING THE FORMATION AND DISAPPEARANCE OF THE DARK BAND

A, a fully developed band three hours after the transverse cut had been made, B, a somewhat shrunken band a day or so after the cut had been made, C, the last traces of a disappearing band about four days after the cut had been made. Parker, 1934

pigment was making its way from the adjacent lightly tinted region into the body of the band.

The blackish bands just described indicate in a very indubitable way that the catfish possesses melanophore nerve-fibers, the cutting of which induces a pronounced and lasting dispersion of the pigment in the color cells. Further evidence of the presence of these nerve-fibers, which in consequence of their action may be called dispersing fibers, is seen in the responses

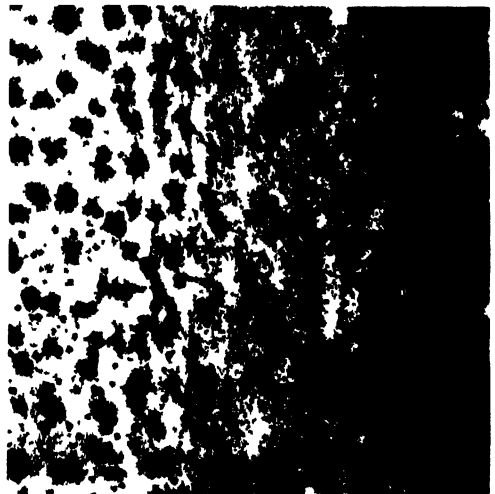


FIG. 15. EDGE OF A RECENTLY INDUCED DARK BAND IN A CATFISH'S TAIL

The contrast between the melanophores with dispersed pigment, which constitute the band itself, and those with concentrated pigment, making up the light area of the fin, is very noticeable. Parker, 1934

hours after the injection of the adrenalin the effect of this substance begins to wear off and the catfish gradually changes from a very light tint to one of moderate darkness. This final stage is arrived at in about five hours. During this recovery the dark band, at first entirely obliterated, also returns and returns in full intensity. This change indicates quite clearly that though the action of the dispersing nerve-fibers was temporarily overpowered by the adrenalin this action was in no sense brought to a standstill. It must have

continued unimpeded for as soon as the action of the adrenalin died out the dark band reappeared. Hence it may be concluded not only that catfishes possess dispersing nerve-fibers but that the severance of these fibers is a stimulus to them of lasting quality.

The fact that catfishes are provided with dispersing nerve-fibers is not, however, ground for assuming that these fish may not have other means of inducing the darkened state, such, for instance, as the pituitary secretions. It seemed, therefore, desirable to test the pituitary gland of the catfish in this respect. Four pituitary glands were removed from four freshly killed catfishes, minced in a few drops of Ringer's solution, and 0.2 cc. of this extract were injected into each of several normal catfishes. To this treatment dark catfishes showed no response. Light catfishes on the other hand began to darken within six minutes and were well darkened in twelve minutes. As there were no color changes in either the dark or the light control catfishes injected with simple Ringer's solution, it is concluded that the pituitary glands of the catfish contain a dispersing neurohumor water-soluble in character that may be effective in exciting the dark phase in this fish.

That this pituitary product is active in helping to darken the skin of the catfish can be shown from the following procedure. It is comparatively easy by using the buccal operation devised for this purpose by Matthews (1933) to reach and remove through the roof of the mouth the pituitary gland of the catfish. Fishes thus operated upon may lose very little blood and, notwithstanding the fact that the base of the brain is exposed to the fluids of the mouth, they will live for as long as two days. If a fish with a denervated caudal band which had been cut two days previously and was now well

faded, is subjected to the removal of the pituitary gland and placed in a dark-walled illuminated vessel, the following conditions will be observed. The whole fish will be seen to darken except the light band. This will retain its original tint thus showing that in the absence of the pituitary gland a denervated area cannot soon turn dark. Such a condition is in strong contrast with that of a fish which has been treated in all respects like the one just described except that the pituitary gland had been left in the animals. Under such circumstances the light band darkens much as the rest of the fish does, showing that the pituitary hormone in the absence of nerves may play the part of a pigment dispersing agent. It seems clear from these tests that not only does the pituitary gland produce a neurohumor capable of dispersing the pigment in melanophores, but that this neurohumor is soluble in blood and may thus be carried to distant regions of the fish's body. If in a catfish with a denervated band darkened by the pituitary hormone a ray and its associated nerves are cut, a characteristic new band soon appears, a band very much darker than that excited by the pituitary substance. It is therefore apparent that of the two methods of exciting the dispersion of melanophore pigment, dispersing nerves and pituitary hormones, the nerves are much the more effective. It appears then that the dark phase of the catfish is ordinarily brought about by a combination of two factors: first, by the dispersing action on the pigment of the melanophores of nerve-fibers that are specially adapted to this end and that act vigorously, and, secondly, by a much less vigorous hormone from the pituitary gland.

If the dark phase of the catfish's skin is to be explained as has just been set forth, what can be said of the light phase? Does the light phase, for instance, involve

special concentrating nerve-fibers and hormones or is this phase merely that of relaxed quiescence? That nerve action may induce a concentration of melanophore pigment has already been shown for the dogfish so that such an agency is at least possible. Furthermore there are several conditions that point quite obviously to the realization of such a state. The narrowing of the dark band in the course of its disappearance in the tail of a catfish is most naturally accounted for on the assumption of the invasion of the band

gradually become dark (Fig. 16). This darkening will not take place, however, if the intermediate band is not denervated. A normally innervated band between two dark bands as can be made by cutting in a light tail two rays one on either side of a given normal ray, does not in time become dark. Hence whether the intermediate band will become dark or remain light depends upon the absence or the presence of nerves. Its darkening, which occurs when it is denervated, would depend then upon the spread of a dispersing

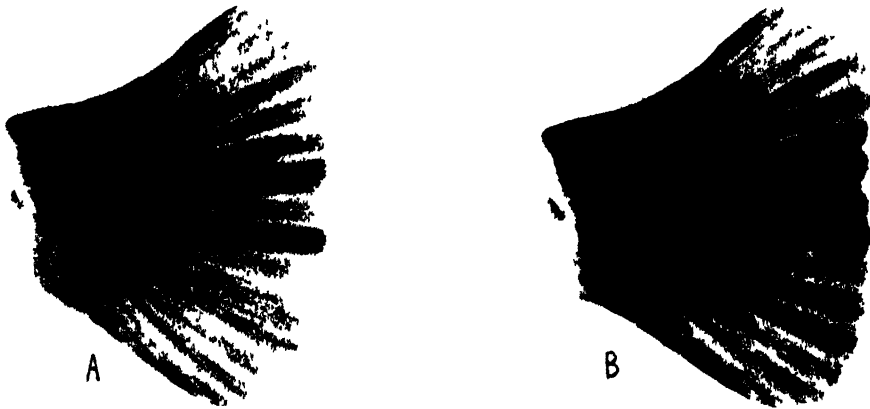


FIG. 16. TWO TAILS OF CATFISHES WITH BANDS ORIGINALLY LIGHT AND INTERVENING IN POSITION BETWEEN TWO DARK BANDS

In *A* the intervening band is still innervated and remains light. In *B* the intervening band, denervated and then allowed to blanch, becomes dark after the formation of the adjacent dark bands. Parker, 1934

by a concentrating neurohumor produced by appropriate nerve-fibers in the adjacent light region. As already stated the disappearing dark band narrows as though it were invaded by just such a neurohumor. That there is something to be said for such an assumption may be seen from the following observations.

If a single radial band in a catfish's tail which in the course of a few days has been allowed to become faded is surrounded by two new dark bands situated one on each side and made by cutting the adjacent rays, the intervening light band will

neurohumor from the adjacent dark bands. Such a neurohumor can act with reasonable rapidity on the melanophores of the light band and brings about the dispersion of their pigment. That this does not occur when the light band is innervated is due, I believe, not to the absence in the light band of the dispersing neurohumor but to the presence there of concentrating nerve-fibers whose action overcomes that of the opposing neurohumor and thus the band is kept light. Hence the maintenance of a light normal band as such between two dark bands calls for the

assumption of concentrating nerve-fibers such as occur in the dogfish when a similar opposing action takes place. The concentrating fibers to a certain degree must be subordinate to the dispersing ones, for when a ray is cut both sets of fibers must be severed and thereby stimulated. In the resultant response it is the dispersing and not the concentrating fibers that assert themselves, for the band becomes dark. I therefore conclude that the stimulus of



FIG. 17 TAIL OF A CATFISH IN WHICH A DENERGATED LIGHT BAND BECAME DARK IN THAT PART WHICH WAS BETWEEN TWO NEWLY DEVELOPED DARK BANDS

Parker, 1934

cutting the nerve is more effective for the dispersing than for the concentrating nerve-fibers.

The evidence that has thus been advanced for the presence of concentrating nerve-fibers involves the assumption of a dispersing neurohumor whereby a light band is invaded and rendered dark. That such a neurohumor is probably present is seen from another type of band comparison. If in a catfish from which the pituitary gland has been removed and in which a faded radial band has been

induced, two new rays are cut so as to bound on each side the distal half only of the faded radial band already formed, this band will in a short time become dark but only in that part which lies between the two new dark bands (Fig. 17). Hence it must be evident that something emanates from these dark bands and induces the darkening of the intermediate one. It is difficult to explain this condition except on the assumption of a dispersing hormone or neurohumor from the adjacent dark bands. I therefore conclude that dispersing nerve-fibers act through a neurohumor that induces both locally and at a distance the dispersion of melanophore pigment. Whether the concentrating fibers act by means of a neurohumor or not is still unsettled.

The following summary may be taken as descriptive of the color changes in the catfish. The dark phase in this fish is induced through dispersing nerve-fibers supplemented by the pituitary gland both acting by means of neurohumors. The light phase cannot be so certainly described, but there is evidence that this phase is dependent upon concentrating nerve-fibers whose action may or may not depend upon neurohumors. The explanation thus advanced implies a double innervation of melanophores. Reasons for the correctness of this assumption will be presented in the discussion of the third and last fish that I wish to consider, namely the killifish, *Fundulus heteroclitus*.

MECHANISM OF COLOR CHANGES IN THE KILLIFISH

The color changes in the killifish have been studied by numerous investigators and over a considerable number of years. Like the catfish the killifish has both a light and a dark phase (Fig. 18). Furthermore small transverse cuts in its tail are followed by the production of dark bands

as in the catfish. In the killifish these bands appear in about half a minute after the cut is made, become strongly pronounced in an hour or so, and then disappear in from two to three days. Such reactions are decidedly more rapid in the



FIG. 18 TWO KILLIFISHES SHOWING IN ONE THE EXTREME DARK PHASE, AND IN THE OTHER THE EXTREME LIGHT PHASE
Parker, 1934

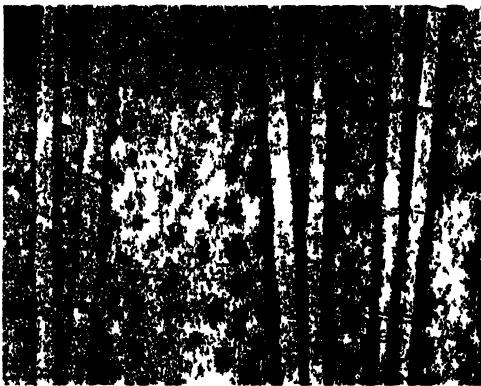


FIG. 19 EDGE OF A DARK BAND IN THE TAIL OF A KILLIFISH HALF AN HOUR AFTER THE BAND HAD BEEN INDUCED BY CUTTING TRANSVERSELY

The contrast between the melanophores with dispersed pigment and those with concentrated pigment is very striking. Parker, 1934

killifish than in the catfish though in other respects the color responses of these two fishes are much the same.

As already stated, about half a minute after a transverse cut is made in the killifish tail the dark band begins to show. The band then quickly reaches its maxi-

mum and at this stage its edges are very sharp. The contrast between the two sets of melanophores at the edge of the



FIG. 20 EDGE OF A DARK BAND IN THE TAIL OF A KILLIFISH 12 HOURS AFTER THE BAND HAD BEEN INDUCED

The sharp contrast between the two sets of melanophores is greatly reduced. Parker, 1934

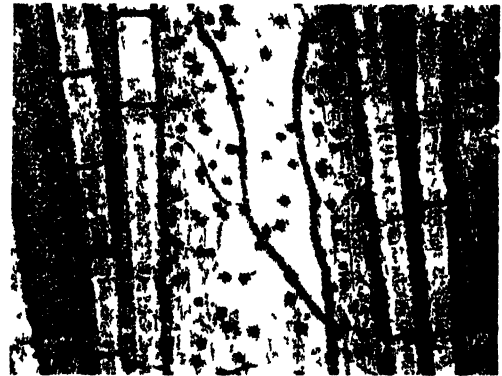


FIG. 21 EDGE OF A DARK BAND IN THE TAIL OF A KILLIFISH 2 DAYS AFTER THE BAND HAD BEEN INDUCED

The original sharp line between the melanophores with dispersed pigment and those with concentrated pigment is quite lost. In this figure the light area in the tail generally is toward the left and the much reduced dark band is toward the right. The pigment in the melanophores at the extreme right of the figure extends somewhat farther into the cell processes than it does in the melanophores of the extreme left. This slight distinction is the last trace of the dark band. Parker, 1934

band, those with dispersed and those with condensed pigment, is very marked (Fig. 19). After twelve hours this edge has

lost much of its distinctness in that its marginal melanophores have assumed an intermediate state between that of the color cells in the dark part of the band and of those in the light area with transitional melanophores in both directions (Fig. 20). After two days the transition from the dark to the light areas is very gradual indeed (Fig. 21) and its center has shifted well toward the axis of the band. Thus a caudal band in the killifish disappears in the course of time by loss of edge and by gradual shrinkage as it does in the catfish and not through simple disappearance as a whole. It does so presumably from the same cause as in the catfish, for it gives every sign of being invaded laterally by an agent that excites the concentration of melanophore pigment, that is, by a concentrating neurohumor.

After the initial band in *Fundulus* has come to be as light-tinted as the rest of the fish, if the fish is now put in an illuminated dark-walled vessel, the whole animal quickly turns dark except the band which at first remains light and only gradually darkens. The body of the fish reaches a full depth of tint in a little less than two hours but it requires about twenty hours for the light band to accomplish the same degree of change. The reciprocal test yields essentially similar results. If a dark killifish with an equally dark band is put in a light environment, the fish as a whole will turn fully light in a little less than five hours but the stripe will require about twenty-six hours for this change. Thus in both instances the band in changing lags well behind the general surface of the fish as though this surface really was the active agent in the change and the band received from it, depending upon the nature of the change, either a dispersing neurohumor or a condensing one.

In these gradual disappearances of the

bands, both light and dark, they are reduced on the edges and not throughout their extent as a whole, thus indicating that the invasion is really a lateral one and not one from the whole under surface of the band. Such a change from below can readily be obtained by adrenalin, for if a killifish with a well developed dark band is injected with this hormone, the band disappears as a whole in less than fifteen minutes and without showing shrinkage at the edge. Adrenalin is soluble in the blood and is carried to the melanophores of the tail by blood and lymph. It bathes the whole deeper surface of any band. Hence its method of approach and the consequent type of disappearance of the band is quite unlike that seen in the natural reactions of the fish where the band diminishes by loss on its edge and not throughout its whole width at once.

The invasion of the band from its edge is further evident in the times required for the disappearance of initial bands of different widths. Ordinarily bands were produced by a transverse cut of one millimeter extent and under such circumstances the bands disappeared on the average in about thirty hours. But when bands were produced by a two millimeter cut the average time of disappearance was found to be some seventy-eight hours. Such a difference should not appear if the band were invaded from its deeper face as well as from its sides but might be expected if the invasion were strictly lateral. With adrenalin both broad bands and narrow ones disappear in the same time, a little less than fifteen minutes.

The possible effects of the pituitary gland and of the blood on the color changes in *Fundulus* have been investigated by several workers including Mills and Matthews. According to Matthews (1933) the loss of the pituitary gland in

no way prevents *Fundulus* from accomplishing its color changes, though the substance of the gland yields a dispersing neurohumor. Apparently this gland in *Fundulus* is without functional significance as a normal means of controlling color changes.

Tests to ascertain the effect of the blood of *Fundulus* on its melanophores have always given negative results. Mills found that the blood from a dark fish when injected into a light one was without influence on the tint of the animal and the same was true in the converse experiment. My own results confirm those of Mills and hence I conclude that notwithstanding the fact that blood and lymph are the means of carrying adrenalin and other such agents, these fluids are not concerned with the transfer of normal neurohumors whereby the bands in the course of hours are slowly changed either light or dark. These changes require too long a time for accomplishment to be attributed to transfer by blood and lymph and must therefore be carried out in some other way. Moreover the agents concerned attack the bands laterally and not from all sides as lymph-carried materials would. Hence I conclude that in *Fundulus* the melanophores are activated by neurohumors, which are not blood-soluble, and which spread with relative slowness from region to region. Such a condition might well be met by an oil-soluble material which, emanating from the numerous activating nerve-terminals in connection with the melanophores, could spread over the lipid surfaces of these and other cells and thus induce in distant melanophores responses appropriate to a given general reaction. Such a view appears to be the most probable explanation thus far offered for these complex relations and in this sense it is to be accepted as a working

hypothesis. It implies a very close anatomical relationship between the nerve terminals on the one hand and their dependent effectors, the melanophores, on the other, as well as a close mutual relation between the several melanophores or other cells in a denervated region. As a matter of fact such intimacy between cells of this kind has already been demonstrated, for, in a recent paper by Herrick (1932) on the melanophores of the tadpole, it has been shown that the processes of melanophores actually anastomose.

If the interrelation of nerves and melanophores for *Fundulus*, as presented in the preceding paragraph, is sound, as it appears to be, it probably also applies to the catfish, for almost exactly the same situations obtain there as in *Fundulus*. The main exception to this statement is found in the fact that in the catfish in addition to a dispersing and a concentrating neurohumor transferred by the lipid surfaces of cells there is also a supplementary dispersing neurohumor, the pituitary, carried by the blood and lymph. Thus the catfish is somewhat more complex than *Fundulus*, which in its turn is not as simple as the dogfish. Here, as already made clear, a pituitary neurohumor is the exclusive means of inducing the dark phase. The light phase, however, is controlled by nerves and may well result from a lipid-soluble neurohumor derived directly from the nerve terminals. From this general standpoint two classes of neurohumors may be distinguished: those soluble in water, that is in blood and lymph, and those soluble in oil such as the lipid constituents of cells. The water-soluble neurohumors act quickly and on the fish as a whole and the oil-soluble ones slowly and more nearly locally.

Water-soluble neurohumors as seen in

the dogfish and in the catfish act as dispersing agents on the melanophore pigment. The assumed oil-soluble neurohumors on the other hand may act either as concentrating agents on this pigment as in all three fishes under consideration or as dispersing factors as in the catfish and the killifish. Since the oil-soluble neurohumors are always associated with nerves the presence of a concentrating type and a dispersing one in this class is at once suggestive of double innervation. That melanophores are doubly innervated has been suspected since the time of Bert (1875) and has been very recently advocated by Smith (1931) and especially by Mills (1932). Smith has shown in *Fundulus* that cocaine, a sympathetic stimulant, induces concentration of pigment in melanophores, and that ergot, a sympathetic depressant, checks this operation. On the other hand pilocarpin, a parasympathetic stimulant, induces dispersion of the pigment and atropin, a parasympathetic depressant, checks dispersion. These results point distinctly toward the double innervation of melanophores, a view to which Mills was led on evidence of an entirely different kind. Mills showed that if the exact distribution of the light and the dark melanophores on the edge of a caudal band is recorded when the whole fish is quickly induced to take on first the light and then the dark tint the two distributions do not agree. In consequence of this lack of agreement two sets of nerve-fibers are to be inferred, one concerned with the dispersion of the melanophore pigment and the other with its concentration. These observations seem to me to afford very substantial support to the idea of double melanophore innervation in which, to use the conventional phraseology, the fibers concerned with pigment concentration would be

classed as sympathetic and those concerned with dispersion as parasympathetic.

CELL-TO-CELL TRANSFER OF SUBSTANCES

The passage of oil-soluble neurohumors gives evidence of a somewhat unsuspected method of transfer of materials within the body of an organism, namely, a transfer from cell to cell. Although this method of the translocation of substances has received only scant attention from biologists, it appears on even a superficial inquiry to be widely spread and, as the following brief survey will show, to be of no small significance.



FIG. 22. TISSUE ON THE EDGE OF A TENTACLE OF *DROSERA* SHOWING A SO-CALLED BUD (B) THROUGH WHICH CAFFEIN HAS MADE ITS WAY INTO THE ADJACENT CELLS AND PASSED TRANSVERSELY AND LONGITUDINALLY THROUGH THE TISSUE AS INDICATED BY THE PARTICLES OF PRECIPITATE SHOWN IN MANY OF THE CELLS

Kok, 1932

Cell-to-cell transfer is known to occur in plants and has been studied recently by Kok (1932). This investigator has shown among other instances that in the tentacles of *Drosophila* the so-called buds mark superficial spots at which caffeine can gain entrance to the underlying tissues whence this drug may spread not only transversely but also distally and proximally through the tentacles (Fig. 22). This transfer of caffeine can be followed from cell to cell in consequence of a precipitate formed in each cell as the drug progresses and its rate has been thus measured by Kok. In the distal direction the caffeine was estimated to travel 658 microns in 30 minutes and in a proximal one 534 microns in the same period. This progression is at a much greater rate than

that which I have found for the neuro-humor of the killifish, namely 9 microns in 30 minutes. The important point in the observations by Kok is the direct evidence of a transfer and from cell to cell, a determination which was only indirectly arrived at in *Fundulus*.

Similar slow transfers have been recorded by Sir Thomas Lewis (1927) in the human skin. If the skin of the forearm of a human being (Fig. 23) is irradiated over a sharply circumscribed area for a brief period of time, an artificial "sun-

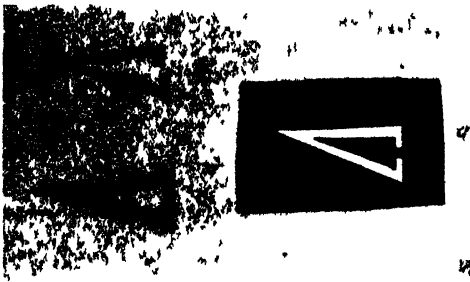


FIG 23 FOREARM OF A HUMAN BEING WITH A METAL SHIELD (A) THROUGH WHICH A PATTERN HAS BEEN CUT FOR USE IN IRRADIATION EXPERIMENTS, WITH A FRESH "BURN" (B) SHOWING RELATIVELY SHARP EDGES PRODUCED BY IRRADIATING THE SKIN THROUGH THE OPENING IN THE METAL SHIELD AND WITH AN OLD "BURN" (C) SHOWING SPREAD AND INDISTINCTNESS OF EDGE

Lewis, 1927

burn" is produced which appears as a reddened patch with sharply marked limits. The reddening is of course due to the enlargement of the subjacent blood-vessels. These vessels respond to the treatment as though they had been acted upon by histamine, and Sir Thomas attributes their enlargement to the local liberation from the irradiated cells of a substance, possibly histamine itself, but which he prefers to call H-substance. In about a day after the irradiation the edges of the reddened area and the redness spread into the adjacent unaffected skin, indicating a slow transfer of the H-substance

from the region of production into the originally undisturbed area. This spread occurs within a period of from twenty to twenty-four hours and over a distance of from two to three millimeters after weak irradiation, of from four to five millimeters after a strong one. The rates obtained from these figures for the spread



FIG 24 PIEBALD SKIN OR VITILIGO IN A YOUNG MAN
Sutton, 1928

of the so-called H-substance are roughly 40 to 100 microns in 30 minutes, approximately midway between those established for *Drosera* (approximately 600 microns in 30 minutes) and for the killifish (about nine microns in 30 minutes). The agreement of these rates, rough though it may be, shows, I believe, that in these and other like instances we are dealing with a common method of material transfer

which from its cellular nature is bound to be in all respects slow.

Other sluggish, localized transmissions through the human skin are seen in the spread of gummy sores or erysipelds. These are sores that occur on the hands of butchers and those who clean fish. They start from slight skin abrasions whence they spread slowly over considerable areas.

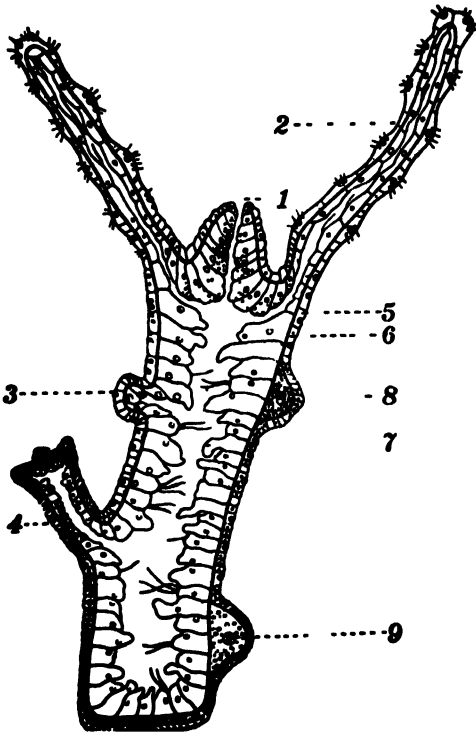


FIG. 25. DIAGRAM OF A LONGITUDINAL SECTION OF A HYDRA SHOWING THE MOUTH (1) LEADING INTO THE DIGESTIVE SAC AND THE SURROUNDING CELLULAR WALLS.

They are apparently not due to infection by germs but to the continuous invasion of the initial abrasion by the decomposition products, probably ptomaines, from meat or the gummy of the fish market. They quickly heal and disappear when the hands of the worker are kept from the offal of the butcher shop. The spread of these sores under continual exposure is so slow as to recall the cell-to-cell trans-

mission already described. Many insect stings follow the same course and spread through the human skin a centimeter or so in several days, finally to retreat slowly to the original center of disturbance. Much the same type of slow spread is

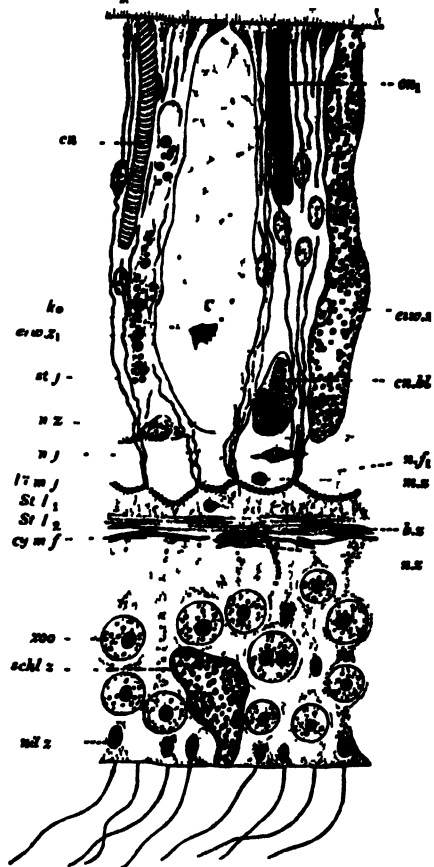


FIG. 26. SECTION THROUGH THE BODY WALL OF A SEA ANEMONE SHOWING THE ENTODERMIC LAYER BELOW AND THE ECTODERMIC LAYER ABOVE WITH ITS MUSCLE CELLS (m z), NERVE CELLS (n z), GLAND CELLS (g z), NETTLE CELLS (c n) AND THE LIKE.

seen in human piebald skin or vitiligo (Fig. 24). The disease, which is far from being understood, creeps over the skin at so slow a rate as to place it possibly in another category of changes from those already discussed. It is, however, interesting as an instance of slow dermal transmission.

Not only is there evidence of sluggish cellular spread of materials among the tissues of the more complex animals including man but such processes appear to be strikingly characteristic of many simple multicellular forms such as the hydra, the sea-anemone, and the whole group of coelenterates. In these animals, as can be clearly seen in the hydra (Fig. 25)

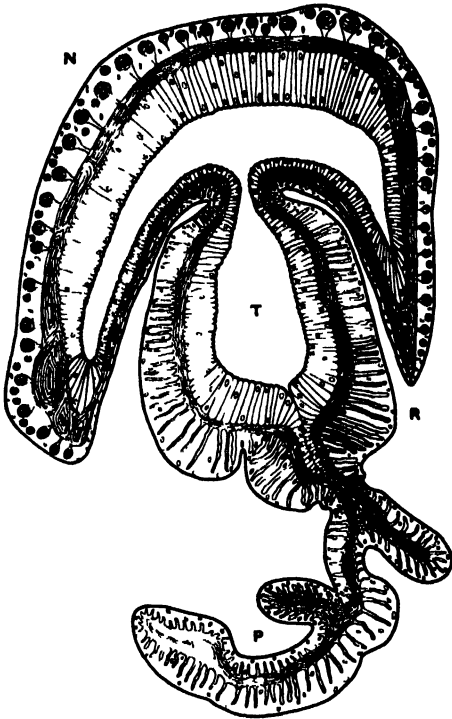


FIG. 27 TRANSVERSE SECTION OF A FISHING FILAMENT OF THE PORTUGUESE MAN-OF-WAR

T, central canal for digestive products, P, muscle plate

many cells are remote from the sources of food supply. In the hydra the food is passed by the tentacles into the mouth and thence to the digestive sac which is the only open space within the animal's body. From this sac the products of digestion must reach even the most distantly situated living cells of this simple organism. The only cells that are in a position to profit at once by this supply of food are those that bound the digestive space, the

entoderm cells. All other cells are at a distance from this supply and as the creature has no circulatory system by which to spread the products of its digestion, these products must be handed on from cell to cell till a sufficiency has reached the most remote elements. Consequently the deep-lying entoderm cells not in contact with the digestive cavity, the entodermic muscle cells, and the whole ectodermic system of protective epithelial cells, nettle cells, gland cells, reproductive cells, muscle and nerve cells can be nourished only by materials that are handed on to them by the cells situated more advantageously in relation to the source of supplies. How considerable this cellular transfer must be is clearly seen in a section of the wall of a sea-anemone's body (Fig. 26) which is much thicker than that of the hydra's body. In the sea-anemone many cells must be involved in the transfer of nourishing materials from the digestive cavity of this animal to its remote elements situated near its outer surfaces and therefore farthest from the source of food.

Another example of the same extensive food transmission in the coelenterates is seen in the fishing filaments of the Portuguese man-of-war. These filaments in this beautiful animal may be many meters in length. Through the center of each one (Fig. 27) runs a canal by which digestive products from the digestive cavity of the polyp may be carried out to the most remote parts of the filament and yet when these products reach the more peripheral regions they are still relatively far from the cells that they must nourish. Many intervening cells lie between the muscles of the filaments, for instance, and the nutritive canal. When it is recalled that muscle is perhaps one of the most actively metabolic tissues of any animal and that in this instance, as shown in the transverse section of the filament (Fig. 27), this

tissue is much of it very remote from the source of food supply in the central canal, it must be at once appreciated how important and significant cellular transmission is. Thus the coelenterates afford examples in which cell-to-cell transfer is apparently a vastly more vital element in their economy than it is in the more complex creatures, and nevertheless there is good reason to assume that this type of transfer has been retained even in such complexly organized animals as man.

In conclusion it may be stated as a result of this survey that there is ample support for the opinion that substances are transmitted through the bodies of plants and

of animals not only by blood, lymph and other similar fluids, but from cell to cell. This method of transmission is believed to occur in organisms from the simplest to the most complex. It is of course much more primitive than that of blood and lymph. In itself it is a relatively slow process but it operates often in connection with other more rapid types of transfer. It is probably an important factor in many of the remarkable operations which take place in embryonic and regenerative growth where transfer of material from one spot to another, as is implied, for instance, in the modern theory of the organizer, takes place.





REDUPLICATION IN EVOLUTION

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INTRODUCTION

IN 1894 William Bateson published his classic work *Materials for the Study of Variation*, in which he stressed the fundamentally important concept that the existence of patterns, defined as exhibiting symmetry with respect to certain points and axes, is a central fact of morphology. He distinguished 'Minor Symmetries,' formed by patterns completed in the several organs or parts, and 'Major Symmetries' which are compounded of minor symmetries. He proposed the term 'Merism' to include the phenomenon of 'Repetition of Parts' in organisms, "generally occurring in such a way as to form a Symmetry or Pattern"; and he noted that this phenomenon "comes near to being a universal character of the bodies of living things."

He then continued to distinguish two main kinds of variations, namely, 'Meristic Variations' and 'Substantive Variations.' As an example of meristic variation he cited the fact that the flower of a *Narcissus* is commonly divided into six parts but through meristic variation it may be divided into seven parts or into only four. As an example of a substantive variation he cites the occurrence of two distinct colors in different species of *Narcissus*.

Bateson, however, considered variability only in its present manifestations. Owing to his reaction against phylogenetic speculation, the chronological or phylogenetic aspect of variability was practically banned by him, especially in his famous Address before the British Association for the Advancement of Science

at Toronto in 1914. In the present paper, on the contrary, certain phases of variability, hereinafter named *polyisomerism* and *anisomerism*, are considered from the phylogenetic viewpoint, in which the available facts of geology, palæontology and zoology are, so far as possible, constantly integrated.

REDUPLICATION AND INEQUALIZATION IN INVERTEBRATES

Trilobites, Crustaceans, Arthropods

The researches of palæontologists, especially those of Walcott, Beecher, Raymond and Leif Störmer (1933) have shown that some of the Cambrian trilobites, including *Triarthrus* (Fig. 1A) were remarkably generalized animals that were apparently near to the direct ancestors of the eurypterids, king crabs (*Limulus*), scorpions and spiders. In another direction they were elated to the ancestors of the Crustacea. The thorax of normal trilobites consists of numerous segments, each of which bears on either side a jointed and usually biramous appendage; each of these paired appendages includes a basal piece or coxopodite from which branch outward two main divisions, an exopodite and an endopodite. The endopodites were used for crawling and consisted usually of six joints. The jointed exopodites were biramous distally, the posterior branch bearing a row of closely appressed gill-blades (Leif Störmer). In any individual trilobite the parts of one thoracic segment are severally comparable with those of other segments. The limbs of crustaceans, according to Leif Störmer, lack the gill-blades of the primitive exopodite, which are preserved in the

more primitive arthropods (e.g., *Limulus*). Thus the common trilobite-crustacean stock is probably Pre-Cambrian in origin.

Trilobites, crustaceans, arthropods, as well as annelid worms, are metameric animals, in so far as they present an antero-posterior series of homologous segments

of budding or subdivision of some parent substance or tissue. Polyisomeres are homologous or comparable parts, either in the same or in different segments or organs, e.g., the different individual gill-blades of a trilobite, either of a single segment or as between different segments.

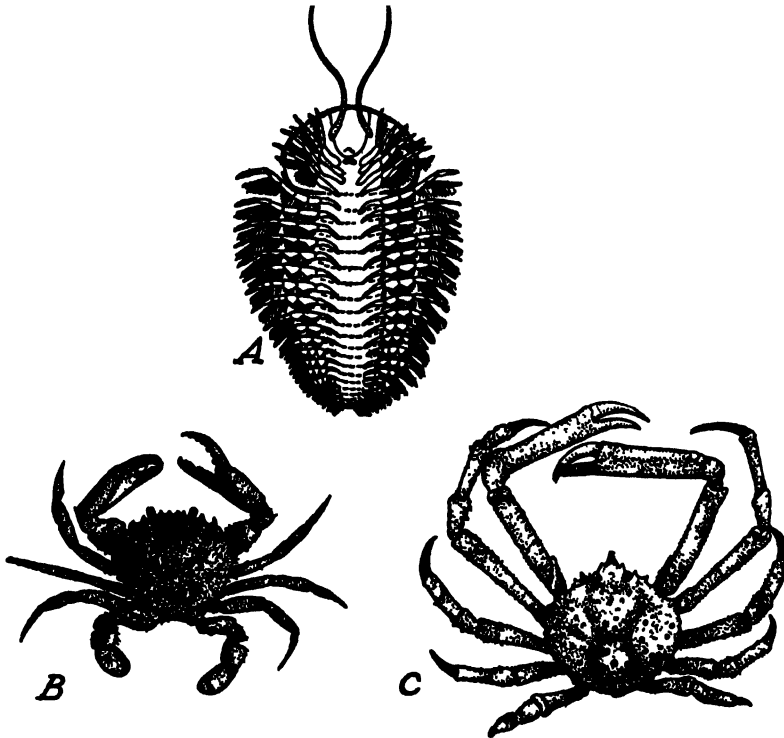


FIG. 1. POLYISOMERISM AND ITS OPPOSITE, ANISOMERISM, IN METAMERIC INVERTEBRATES

A. Primitive Cambrian trilobite, *Triarthrus becks*. After Beecher. Under side, showing primitive longitudinal and transverse polyisomerism.

B. Modern crab (*Platyonichus ocellatus*). After A. G. Mayer. Dorsal side, showing high degree of anisomerism.

C. Spider crab (*Libinia dubia*). After A. G. Mayer. Dorsal side, showing secondary polyisomerism by convergence.

extending symmetrically on either side of the long axis of the body. Metamerism is, however, only a special case of polyisomerism, or reduplication, which may be defined as the state in which many homologous parts are arranged along any primary or secondary axis, anteroposterior, transverse, vertical, spiral, etc. Polyisomerism evidently results from a process

Thus we may have interorganic polyisomerism or intraorganic polyisomerism.

If we now compare a modern lady-crab (*Platyonichus ocellatus*, Fig. 1B) with the primitive trilobite, we shall note that in the crab a number of the thoracic segments have fused with the head to form a cephalo-thorax, while the appendages have acquired a marked regional differen-

tiation, so that, for example, the powerful claws armed with sharp tooth-like projections on their "jaws" are quite different in general appearance from the walking legs and these again from the paddle-like appendages at the rear end. Here then is an example of true differentiation or *anisomerism*, which has grown out of a state of undifferentiation or primary *polyisomerism*.

Such local differentiation of homologous parts is due in part to heterogony, or differ-

ondary polyisomerism by convergence of a type which is extremely frequent throughout the animal and plant kingdoms.

There seems to be good evidence that the trilobite stock gave rise to the Silurian eurypterids and that some of these in turn produced the Silurian and later scorpions and spiders, while certain others are represented today in the king crab (*Limulus*), which is thus a 'living fossil' of the highest antiquity. In the higher arthropods the originally polyisomeric

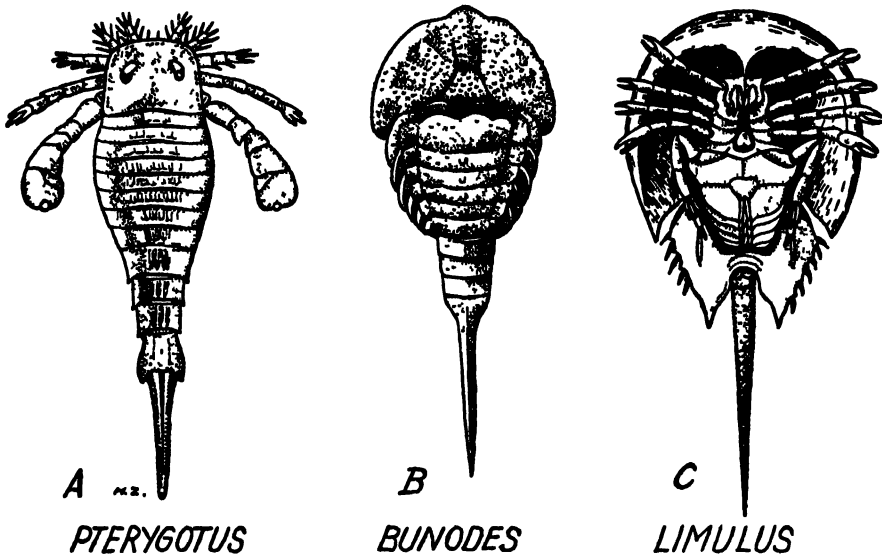


FIG. 2. POLYISOMERISM AND ANISOMERISM IN PRIMITIVE ARACHNIDS

A. *Pterygotus anglicus*. From Abel, after H. Woodward.

B. *Bunodus lunula*. After restoration by Patten.

C. *Limulus polyphemus*. After Abel. Under side, showing anisomerism of head-shield and thorax.

ences in growth rates in different segments as compared with the body as a whole (J. S. Huxley, 1932, p. 8).

If next we compare an ordinary crab with a spider crab (Fig. 1C) we note that in the latter the exoskeleton is covered with numerous small excrescences and that the very long appendages in a general way look much alike, so that the really high specialization of this form is masked by a false impression of uniformity or lack of differentiation. This is an example of sec-

ondary polyisomerism by convergence of a type which is extremely frequent throughout the animal and plant kingdoms. There seems to be good evidence that the trilobite stock gave rise to the Silurian eurypterids and that some of these in turn produced the Silurian and later scorpions and spiders, while certain others are represented today in the king crab (*Limulus*), which is thus a 'living fossil' of the highest antiquity. In the higher arthropods the originally polyisomeric

He also showed how (Fig. 3), according to his theory, the shield and paired eyes of the primitive eurypterid grew around on to the opposite side of the animal and the eyes turned inside out to produce the paired eyes of the earliest ostracoderms; how the several cranial nerves of the arachnids were transformed into those of the typical vertebrates. But after many years of fairly frequent and close study of

To palæontologists both Patten's and Gaskell's theories must stand at present as capital examples of the power of convergence and of mere coincidence to produce deceptive similarities between widely unrelated forms. In other words, it appears that independently in the Arthropoda and in the Chordata the progressive evolution of a complex locomotor apparatus along somewhat similar lines

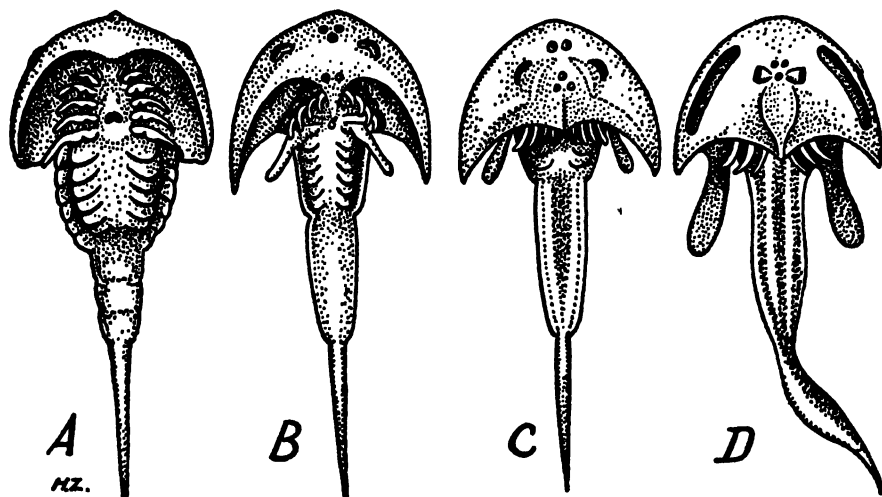


FIG. 3. PATTEN'S THEORY OF THE ORIGIN OF THE VERTEBRATES
After Patten

A. Diagram of hypothetical marine arachnid, based chiefly on *Bunodes lunula*. The animal is lying on its "back," or functionally dorsal surface, revealing the primitive mouth and paired appendages.

B, C. Hypothetical stages showing the overgrowth of the shield on to the originally ventral surface, which gives rise to the dorsal surface of a vertebrate. The overgrowth of the shield is referred to a great increase and coalescence of the neuromeres beneath it. The cephalic appendages give rise to the extrabranchial cartilages and postoccipital appendages.

D. Larval ostracoderm (*Cephalaspis*), showing complete transmigration of the shield and paired eyes on to the now dorsal surface.

From the palæontological viewpoint there is little warrant for the postulation of either such a major shift of the shield or the derivation of the vertebrate branchial skeleton from cephalic appendages.

Professor Patten's theory I am unable to accept his proposed homologies between the cranial nerves of arachnids and those of vertebrates. Gaskell's version of the arthropod theory of the origin of vertebrates, while equally ingenious, requires even greater demands upon our credulity in accepting its drastic transformations of the primitive gut of arthropods into the lining of the neural tube of vertebrates (cf. Delage and Hérourard, 1898, p. 350).

required a more and more complex control system; that is, a primitive state of polyisomerism in the locomotor parts and their corresponding nerve segments, through emphasis, concrescence and loss of parts, gradually gave way to differentiation or anisomerism in both phyla. But in spite of the convergence in external appearance between eurypterids and ostracoderms it must be admitted that the brain and cranial nerves of *Limulus* are

profoundly different from those of the larval lamprey or even from those of the Devonian ostracoderms as described by Stensiö.

The mouth-parts of invertebrates show

annelids, echinoderms, etc., serve to drive a current of water into the mouth. Here the polyisomerism of the cilia is evident.

The starting-point for the more or less complex jaw-parts of crustaceans, arach-

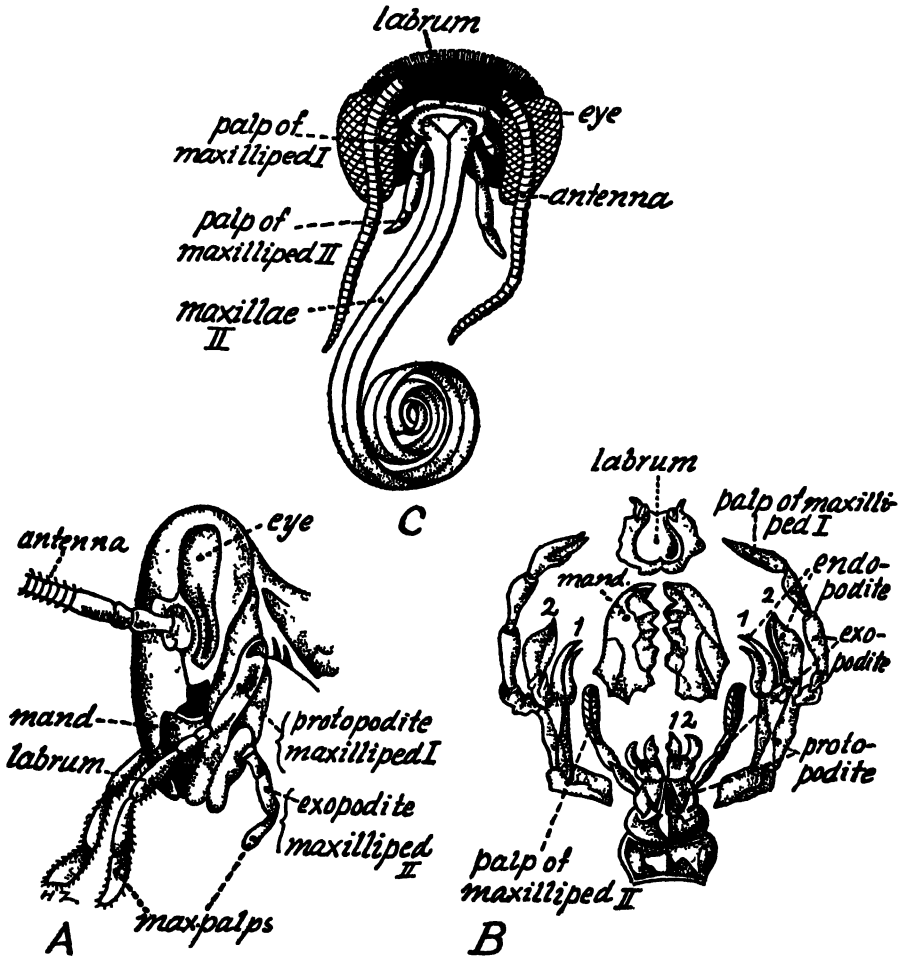


FIG. 4. POLYISOMERISM AND ANISOMERISM IN THE MOUTH PARTS OF INSECTS

Modified from Parker and Haswell, after Lang

A. Head of cockroach, showing maxillary palps derived from exopodites of cephalic appendages.

B. Mouth parts of cockroach, showing primitive relations of exopodites and endopodites to protopodites.

C. Extreme anisomerism in mouth parts of Lepidoptera, showing proboscis made up of the fused endopodites (maxillae) of "maxilliped II."

the same principles of growth and evolution as do their varied locomotor apparatus. Perhaps the simplest forerunners of jaw-parts are the ciliated bands which in various Protozoa and in the larvae of

nids and insects is to be seen in the much more primitive conditions in trilobites, where the functional jaws are merely the proximal parts of the first two pairs of segmental appendages.

It has long been known that among the insects there are many steps from the primitively isomeric mouth-parts of the cockroaches (Fig. 4A, B) to the excessively specialized anisomeric mouth-parts of the Lepidoptera (Fig. 4C).

Molluscs

Although molluscs are not metameric animals they often display serial repeti-

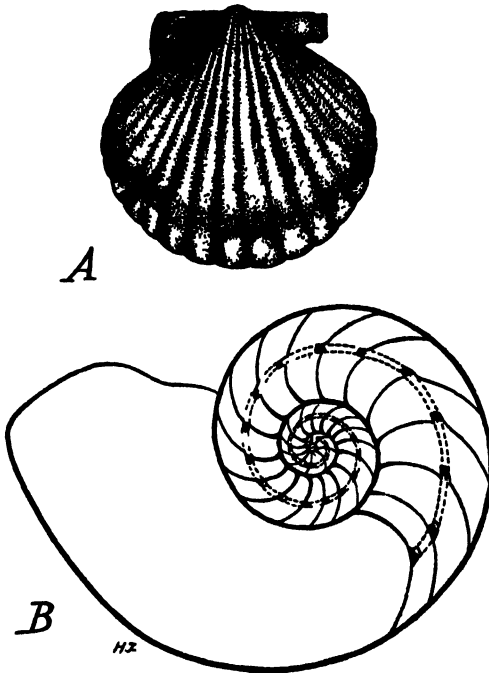


FIG. 5. SECONDARY POLYISOMERISM IN MOLLUSCS

A. Radial polyisomerism in *Pecten*. After A. G. Mayer.

B. Spiral polyisomerism in *Nautilus*. Section of shell, after Parker and Haswell.

tions of certain features which are an expression of the phenomenon here called secondary polyisomerism, following upon an earlier anisomerism: for example, the ridges or folding of the shells of many pelecypods or the eyes on the mantle of scallops. Such alternate elevations and depressions imply temporal acceleration of growth and spatial distribution of neutral nodes, which processes seem to be among

the causes of polyisomerism. Secondary polyisomerism is beautifully illustrated in the successive chambers of cephalopods. In the more elaborate types of sutures of fossil nautiloid shells we witness the evolution of polyisomerism of the second, third and even higher orders.

There seems to be good evidence that the primitive mollusc was bilaterally symmetrical until a constant difference in growth rates of the two sides of the mantle conditioned what might be called a spiral symmetry.

Thus polyisomerism is due to the summation of rhythmic pulses of growth operating in tissues of more or less homogeneous material, i.e., in any of the three primary germ layers or their products. Hence polyisomerism, as a direct result of rhythm in cell division, is perhaps as fundamental and far-reaching a property of living things as growth and subdivision.

The opposite phenomenon, anisomerism, is due to the undue emphasis or prolongation of growth of certain parts, which are thus thrown out of harmony with the rest. A more remote contributing cause of polyisomerism and its opposite may be the diurnal and seasonal variations in the environment, as clearly registered in the lines of growth in shells, fish scales and tree trunks.

The highly organized radula, or rasp, of predatory molluscs includes a great number of tiny denticles arranged in various ways in longitudinal rows on a movable, strap-like tongue, which can be jerked back and forth over the shell of the victim. These polyisomeric denticles are also diagnostic in different species and genera, and here we notice the obvious but fundamentally important fact that polyisomers are always specific or even individual, so that although the processes that produce polyisomerism may be similar or identical in different cases, the material that goes

into the product is always specific and diagnostic, possibly even of the individual, if sufficiently delicate tests of age and nutritional factors were available.

Echinoderms

The combined results of long periods of polyisomerism, anisomerism and secondary polyisomerism in the arthropod group and their allies have produced many extraordinary types of body, but in the echinoderms still more amazing transfor-

with five well developed "arms" may be more primitive than the asymmetrical bag-like *Aristocystites*. These five arms, which were of course primarily like the puckered corners of the bell-like mouth of a jelly-fish, were of great functional importance in collecting and passing along minute food particles to the mouth. From the first they exhibited a pentamerous polyisomerism, not only in respect to their general ground-plan but in the comparison of their extremely numerous small parts, such as

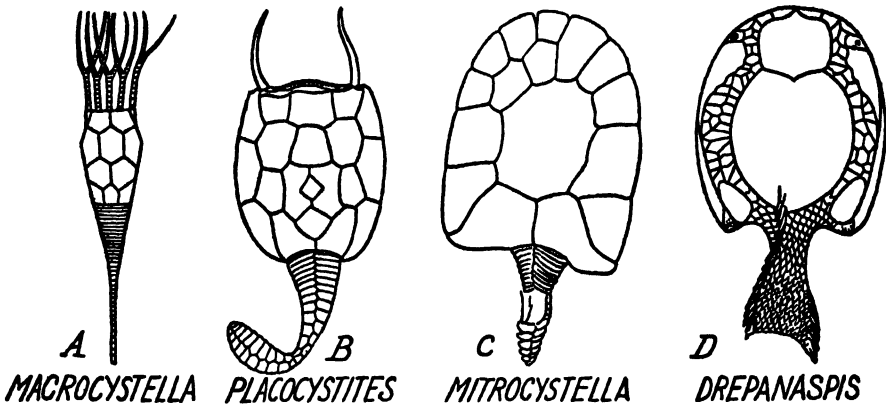


FIG. 6. COMPARISON OF ECHINODERMS AND PRIMITIVE CHORDATÆ

A. Relatively primitive cystoid, *Macrocystella*. After E. W. Berry. Showing quincunciate polyisomerism.

B. Upper Silurian carpod, *Placocystites forbesi*. From Abel, after Bather. Showing secondary dorso-ventral asymmetry and bilateral symmetry.

C. Lower Silurian carpod, *Mitrocystella barrandei*. From Abel, after O. Jaekel. Showing dorso-ventral asymmetry and incomplete bilaterality.

D. Devonian ostracoderm, *Drepanaspis*. From Zittel, after Traquair. Showing nearly complete bilaterality.

mations have been attained by the accumulation of an infinite number of small steps. On account of the bilaterality of the larva of *Antedon* it is believed by high authorities that the radiate symmetry of echinoderms was first developed in adaptation to sessile life by an early bilateral and free-moving pre-echinoderm. While that may well be true of the pre-echinoderms, by the time the echinoderms themselves first became known in geological history they were already attached forms and it is even possible that some of the early sea-lilies

the tube-feet, ampullæ and supporting plates. Contact of the larva with the ground, however, induced a marked regional anisomerism manifested by the outgrowth of an attaching organ or stalk, which eventually in its turn became secondarily polyisomeric.

However, with the instability and as it were recklessness that characterizes Nature, some of the beautiful sea-lilies sacrificed their five-rayed symmetry by habitually bending over on one side. As the calyx touched the bottom on one

side and the race gradually became adjusted to this new position, a dorso-ventral asymmetry was gradually imposed, together with a cephalo-caudal asymmetry and eventually a bilateral symmetry. Several stages in this process are seen in the early group of echinoderms called Carpoidea. Thanks chiefly to the researches of Bather in England and Jackel in Germany, many genera of these queer lop-sided creatures have been made known to science and an excellent brief review of the group may be found in O. Abel's *Lehrbuch der Paläontologie* (1920, pp. 280, 281). When the calyx was bent over and acquired a dorso-ventral asymmetry it developed a bilateral articulation with the stalk, which in turn tended toward bilateral symmetry, while the lower end of the latter, formerly serving as a kind of root, acquired a spatulate, tail-like expansion. Meanwhile, as a result of the induced tendency toward dorso-ventral asymmetry and bilateral symmetry of the calyx, certain genera (e.g., *Placocystites*, *Mastrocystella*, Fig. 6) began to display a somewhat vague suggestion of the general appearance of the "head shield" of certain ostracoderms (e.g., *Drepanaspis*, Fig. 6), while the stalk, as above noted, furnishes an amusing suggestion of an ostracoderm tail.

In another carpod named *Cothurnocystis* the calyx is markedly asymmetrical, bearing on one side a row of small openings (Fig. 7) which Dr. Torsten Gislén (1930) has compared with the asymmetrical gill-openings of the larva of *Amphioxus*.

Of course we cannot yet be sure that all these resemblances are not due to the "long arm of coincidence," which has brought about hosts of what the late Professor Bashford Dean (1908) called "Unnatural History Resemblances," such as the "crucifix" on the underside of the skull of certain catfishes, the "samurai's

face" on the back of certain Japanese crabs and the "Arabic inscription" on the tail of a certain fish. And whenever such spurious resemblances are pointed out the memory is quick to supply additional "evidence" from independent quarters. So also in the case of the ostracoderm-like appearance of some of the carpod echinoderms we recall that zoologists have long suspected that there was a remote connec-

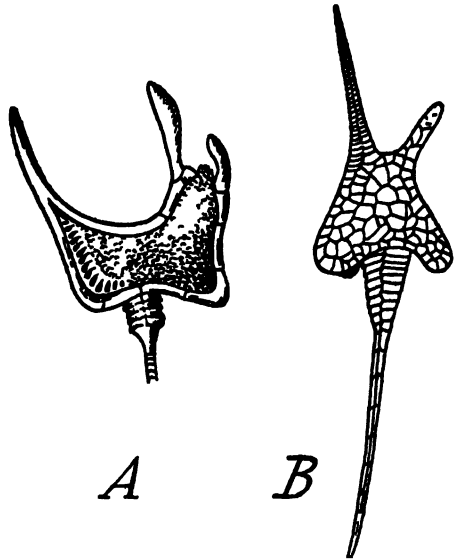


FIG. 7 ASYMMETRICAL SILURIAN CARPOIDS
From Abel, after Bather

A *Cothurnocystis elzæ* Showing marked asymmetry and supposed mouth openings (? branchial openings)

B *Dendrocystites scotticus* Showing tail-like stalk. The marked asymmetry and general appearance is somewhat suggestive of an ascidian larva.

tion between the echinoderms and the vertebrates, not only because of the "Tornaria" larva of *Balanoglossus*, which resembles that of certain echinoderms, but also because both form their mesoderm from enterocoelic pouches.

Meanwhile it must be admitted that so far as known there is a profound morphological gap between any known echinoderm and the oldest known vertebrates. This would be still more con-

spicuous if proof were found for Jaekel's view (quoted by Abel, 1920, p. 279) that the reduction of the mouth-plate in the carpoids is correlated with the evagination of the gut in front of the mouth, as occasionally happens in the holothurians, so that the food was both caught and digested outside the body! Nevertheless even greater miracles seem to have happened than the hypothetical loss of the preoral part of the gut and the development of a new mouth, transformations long ago demanded by embryologists. An echinoderm that had lost its arms would have left only a sac-like gut with a minimum of nervous system. It would thus have far less to get rid of as a preliminary

Aristotle's lantern in the sea-urchin is made up of five sets of tooth-like plates with several rows of supporting plates and lever arms, operated by five principal muscles and a number of accessory muscles and their controlling nerves—all set in a ring around the mouth. If taken to pieces by an amateur this amazing example of so-called "design in nature" might prove as distressingly polyisomeric as the parts of a radial motor of an airplane.

The complexities of Aristotle's lantern seem to have been too much for even Nature herself to modify successfully, for so far as I can gather from the literature it is found only in the sea-urchins and holothurians.

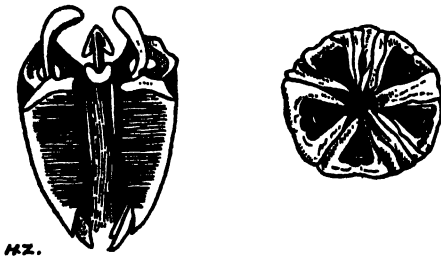


FIG. 8. "ARISTOTLE'S LANTERN"

After Parker and Haswell. Showing quinquediate polyisomerism

before starting on the upward road to the vertebrates than would the far more highly organized arthropods.

Consequently the nascent "Carpoid theory" of the origin of the vertebrates, which no one except Dr. Torsten Gislén has as yet had the courage even to imply, may eventually prove to be the final key to the classical problem of the origin of the vertebrates.

We have already noted that the five arms of primitive sea-lilies are practically projecting folds around the mouth. Thus the tube-feet in the "arms" of the starfishes now serve as locomotor organs by a change of function.

The beautiful mechanism known as

Protochordates

Balanoglossus and the ascidians, derived, doubtless at different times, from the earliest echinoderm-chordate forerunners, are each highly specialized and in some respects degenerate but in different ways. While *Balanoglossus* is perhaps a protochordate masquerading under the habitus of a marine worm, the colonial sessile ascidians are protochordates almost transformed into the condition of corals or bryozoöns. But for all that, the *Balanoglossus* group seems to reveal its kinship on the one hand with the echinoderms through the *Tornaria* larva of its typical species and on the other hand with *Amphioxus* through the three-pouched larva of other species, while the ascidians retain their connection with *Amphioxus* through the mode of formation of their mesoderm, the expanded pharynx with its many gill-openings and the presence of a true notochord in the larval stage.

Each of the protochordates exhibits a high degree of polyisomerism in certain parts and in different ways. Thus in the adult *Balanoglossus* the numerous branchial organs are made up of elongate U-shaped

slits with little horizontal bars connecting adjacent U's. The details of the branchial apparatus differ in the four genera of balanoglossids (Delage and Hérourard, *Les Procordés*, Pl. IV and Fig. 34). The plates of Delage and Hérourard also illustrate the polyisomerism of the cells composing any given organ and we realize that macroscopic polyisomerism depends upon the homogeneity of the microscopic components. The *Tornaria* larva of *Balanoglossus* shows a highly polyisomeric arrangement of its ciliated bands.

Amphioxus.—Perhaps the highest degree of secondary intraorganic polyisomerism is attained in the fish-like *Amphioxus*, not only in its very numerous myomeres and gonads but in its multitude of tactile cirri, its greatly expanded pharynx and high number of gill-bars. The peculiar asymmetry of the developing gill-bars, as noted above, has been compared by Torsten Gislén with the asymmetry of certain fossil echinoderms (Fig. 7); but if the protochordates have indeed been derived from the carpoid echinoderms (see p. 280 above) the transformation has completely wiped out all traces in the adult *Amphioxus*; in this connection it will be realized that as the condition here called secondary polyisomerism advances it submerges the ancient anisomeric heritage of earlier ages.

The polyisomeric ciliated bands that form the endostyle in ascidians, in *Amphioxus* and in the larval lamprey perhaps date back to a period before any kind of jaws developed, when microscopic food was ingested by the action of cilia.

Ascidians.—The ascidians also supply us with examples of the principle that a primitive state of polyisomerism may give rise to a stage of anisomerism or differentiation and that this in turn may be replaced by a secondary polyisomerism. For example, it is not impossible that the simple tunicates (Fig. 9A) as an offshoot

of the chordate stem and ultimately of the echinoderm stock, may represent a secondary return to a sessile mode of life. As a sessile animal such a typical simple ascidian is strongly anisomeric in its twisted digestive tract and localized gonads. But by breaking loose from its base (Fig. 9B) and budding in chains, a *Salpa* colony (Fig. 9C) as a whole has become secondarily polyisomeric.

Since polyisomerism may be either primary or secondary we can not hope to distinguish between the two merely by inspection of a given type without regard to the taxonomy and phylogeny of the group. Amateur students of evolution have often been misled by Herbert Spencer's classic concept of evolution as implying progress from homogeneity to heterogeneity, from simplicity to complexity. We now know from hundreds of well established instances that simplicity may often be the reverse of primitiveness and that progress, at least in the later chapters of evolution, has often been from a state of high local differentiation or anisomerism to the deceptively generalized-looking simplicity of secondary polyisomerism.

REDUPLICATION IN THE LOCOMOTOR SKELETON OF VERTEBRATES

The locomotor skeleton of vertebrates has evolved in relation to the arrangement of the zig-zag myomeres and to the septa between them. These myomeres are themselves products of lateral pouches from the primitive gut, so it is not surprising that they should be found in close functional connection with the median out-pocketing of the gut, which is the primitive notochord. But whereas the myotomes very early become polyisomeric, the notochord is unsegmented and continuous from the hypophysial sac to the tip of the tail. The notochord, composed of thin-walled

cells turgid with liquid contents and covered with an elastic sheath, affords the necessary resiliency and reaction against the rhythmic contractions of the myomeres.

served impressions of the posterior half of the body show an empty space in the midline beneath the longitudinal dorsal fin-fold and between the dorsal and ventral rows of small rod-like supports of the

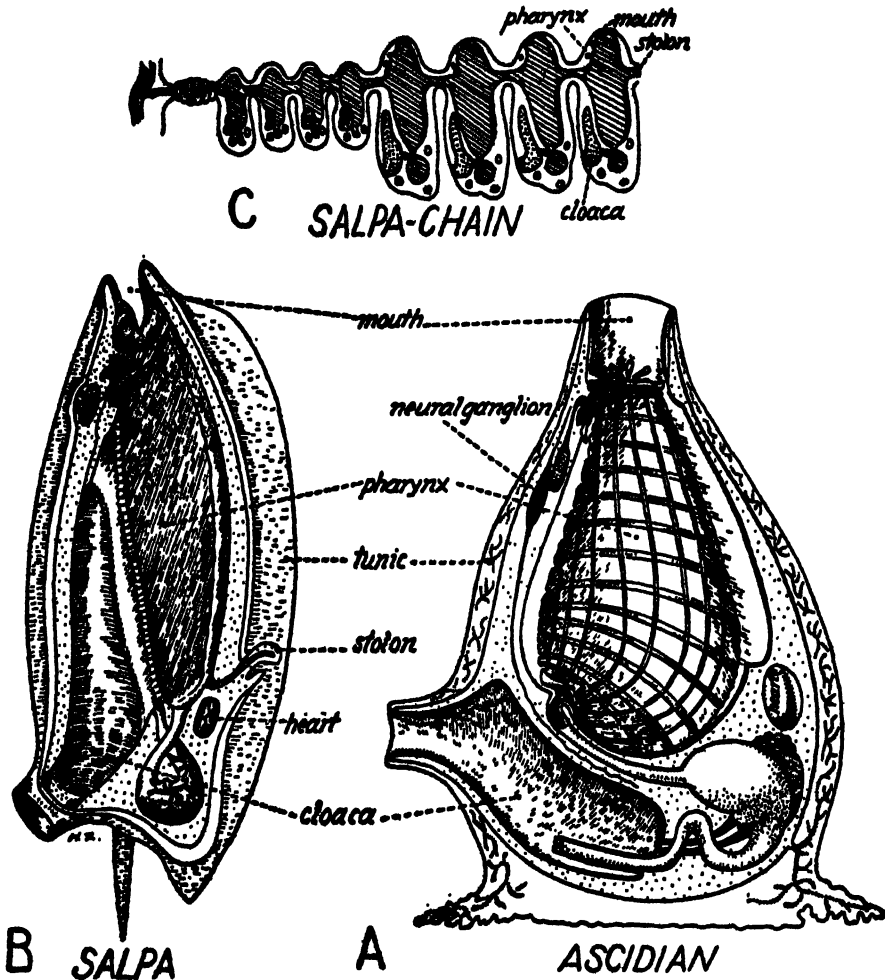


FIG. 9. ANISOMEROUS AND POLYOMEROUS ASCIDIANS

After Delage and Hérourard

The primitive state of the notochord, as exhibited in *Amphioxus*, was doubtless also characteristic of the ostracoderms, in which there is a tube for the notochord behind the hypophyseal fossa (Stensiö, 1927, Pl. 79). In another group of early chordates, the Antiarchi, several well pre-

caudal fin. These spaces can hardly have been filled by anything but the notochord.

In the elasmobranchs the thick outer or fibrous sheath of the notochord was invaded by skeletogenous cells which proceeded to lay down four pairs of blocks, two dorsal and two ventral, in each

sclerotome or primitive mesodermal segment. According to Gadow (1895), the anterior dorsal and ventral blocks were at the posterior end of one segment just in front of the intersection of the oblique septa of the myomeres with the elastic sheath of the notochord, while the posterior dorsal and ventral blocks were behind this septum and at the front end of the next segment. Goodrich (1930), however, dissents from this and holds that all four pairs belong within one segment. The two dorsal pairs (basidorsals and interdorsals) rest on the dorsal half of the elastic sheath and protect the spinal cord, while the two ventral pairs (basiventral and interventral) rest against the lower half of the fibrous sheath (Goodrich, 1930, p. 18). These vertebral blocks or arches not only protect the spinal cord and nerve exits but also serve as bases for the attachments of the myomeres. Those parts of the blocks that surround the notochord coalesce to form short cylindrical centra.

The vertebral centra of sharks exhibit a high degree of intersegmental polyisomerism as well as intrasegmental polyisomerism. Their diverse patterns, afforded by the deposition of calcareous material presumably along the zones and lines of greatest stress, are in general characteristic of the various groups of elasmobranchs and have been exhaustively treated in a great monograph by Hasse.

In the chimaeroids, which are highly specialized elasmobranchs, the central portion of the vertebral column attains a stage of secondary hyperpolyisomerism, as it is composed of a very large number of similar rings. In the embolomeric type of vertebrae, characteristic of the earliest known amphibians, each vertebra consists of two checker-like discs perforated by the notochord, the second one bearing the massive neural arch. The polyisomeric

ribs, which function as lateral extensions of the vertebrae for the insertion of the lateral muscles of the myomeres, are movably articulated with the centra by two processes or heads, of which the lower or capitulum is articulated with the intercentrum; the upper or tuberculum articulates with the diapophysis of the neural arch (Watson, 1925). The neural arches articulate with each other by means of inclined paired facettes or zygapophyses, the function of which is to prevent strangulation of the spinal cord and spinal nerves during flexure of the body.

In the more ancient stegocephalian amphibians from the Lower Carboniferous there was also a high degree of primitive intersegmental polyisomerism from one end of the backbone to the other (Fig. 10). At the same time we see in these forms the beginning of regional anisomerism, since there is a rather rapid reduction of the ribs as we pass backward in the lumbar region to the sacrum and then a sudden marked increase in size of the two ribs that are expanded as a sacrum to receive the thrusts of the pelvic limbs transmitted through the pelvis. Again, behind the sacrum there is a rapid constriction of the intercostal diameter as the posterior ventral ribs, or haemopophyses, enclose only the postanal main blood-vessels.

At the other end of the vertebrate series in man, we find a high degree of regional anisomerism in the backbone, combined however with a considerable degree of intraregional secondary polyisomerism. Thus there is a sharp differentiation between the atlas and axis, between the seventh cervical and the first dorsal, between the last dorsal and the first lumbar, the last lumbar and the sacrum. In the postsacral vertebrae, especially where they are coalesced into the coccyx, the polyisomerism is partly secondary.

The great flying reptile *Pteranodon* ex-



FIG. 10. MODEL OF AN EMBOLOMEROUS AMPHIBIAN, DIPLOVERTEBRON

Based on skeletons described by D. M. S. Watson. Showing primary polyisomerism and slight regional anisomerism in axial skeleton.

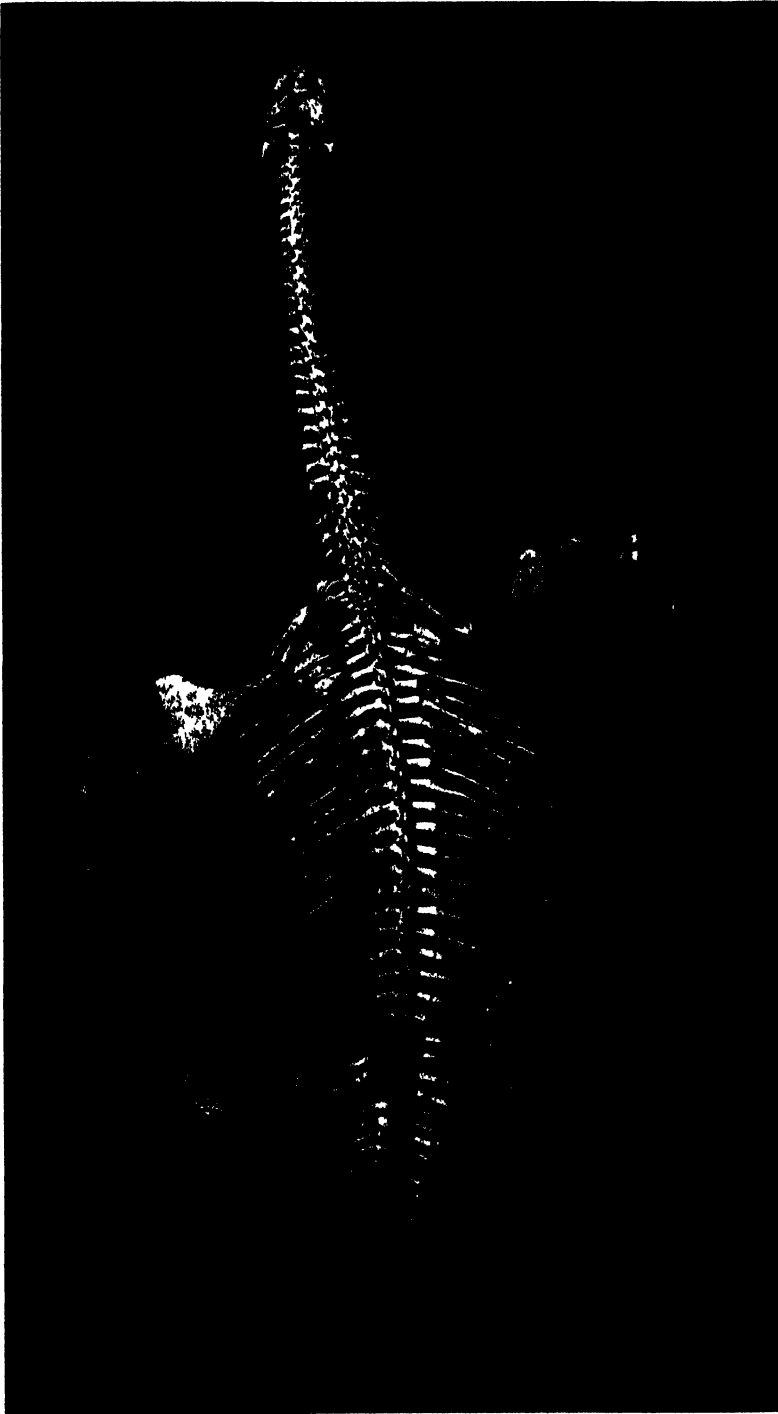


FIG. 11. SKELETON OF PLESIOSAUR, *CRYPTOCLEIDUS OXONIENSIS*

Mounted in the American Museum of Natural History by Charles Lang. Photograph by A. E. Anderson. Shows marked secondary polyisomerism tending to obscure an earlier anisomerism.

hibits a high degree of regional anisomerism in the backbone, for here a number of the anterior thoracic vertebrae are coalesced into a pseudo-sacrum to receive the thrusts of the enormous pectoral limbs, while many vertebrae in the sacral region are coalesced to form a synsacrum. Even here, however, there is also a considerable degree of intraregional polyisomerism.

Secondary polyisomerism in the backbone of vertebrates is quite common; for example, among fishes we have an extraordinary hyperpolyisomerism of the column in the morays and in other anguilliform fishes of several orders. Again in the class Amphibia many exhibit this feature in a high degree, especially among the early stegocephalians and Lepospondyli as well as in such urodeles as *Necturus*, *Siren*, and in the entire order of coecilians. The same principle ran riot among the reptiles, which produced many long-bodied, small-limbed and eventually limbless forms like the glass snakes and amphisbaenians among the lizards, as well as the true serpents.

Various phyla of extinct land-living reptiles gradually became aquatic and some of them even marine in habits. As they did so, the limbs were transformed into paddles and the backbone usually became de-differentiated and secondarily polyisomeric, so that in the ichthyosaurs, for example, the centra were simple and checker-like from one end of the column to the other, nearly all traces of the sacral differentiation being obliterated. Similarly the neural arches became alike and reduced their zygapophyses, thereby facilitating the free undulation of the backbone.

In the plesiosaurs there was also a rather high degree of partly secondary polyisomerism in the elements of both the axial and the appendicular parts of the skeleton (Fig. 11).

In many cases of excessive polyisomer-

ism of the backbone (due apparently to a multiplication of the muscle segments) there is also a corresponding polyisomerism of the integument, frequently producing rings or a regular arrangement of spots. As a result of intrasegmental anisomerism combined with intersegmental polyisomerism, one or more elements of a pattern may be stressed at an early stage of development. Subsequent growth and elongation pull out these color patches into various component parts, so that we finally witness the beautiful color patterns of the pythons and vipers. The feathers of perhaps every species of birds would furnish many examples of inter- and intraregional polyisomerism and of the opposite tendency toward anisomerism but always with a specific or individual stamp of the resulting patterns. In the phenomenon called aquitocubitalism in birds, for example, which implies the presence of fifteen primary flight feathers on each wing, a great number of species, genera and even orders of birds exhibit a general polyisomerism of these feathers, combined with specific differences in the colors, patterns and forms of the overlying wing coverts.

The accessory locomotor organs, including the fins, paddles and finally limbs, likewise go through the stage of primitive polyisomerism and anisomerism, followed by either hyper-polyisomerism or hyper-anisomerism. Thus the pectoral and pelvic fins were once part of either continuous or nodally projecting paired finfolds, supported in the earliest fishes by spines or cartilaginous rods. These paired fins were originally of the same nature as the median fins and included rigid projections of the body-wall enclosing the segmental muscles and surmounted by crests of integument strengthened by rows of denticles coalesced into spines or fin-rays.

There was, however, one enduring rea-

son for anisomerism between the pectoral and the pelvic girdles, for the former was originally associated with the head and formed the boundary between the body musculature and the orobranchial chamber, while the pelvis was associated with the exit of the digestive and reproductive tubes and was thus situated on a node of the musculature between the flanks and the tail. Also the pectoral limbs, except among the pterosaurs, never acquired an attachment to the column, whereas the pelvic limbs by the upgrowth of the ilium gained a ligamentous contact with the

girdle into anterior, dorsal and posterior elements. Such triradial sutures in the case of fish skulls arise through the mutual pressure of three bony centers which are being pushed away from each other by their equal growth rates and by the reactions generated at their intersecting peripheries.

The distal ends of the paired fins were originally polyisomeric in so far as they were supported by serially arranged muscles and skeletal rods. By coalescence of some of these serial elements the base became constricted and the fin gradually

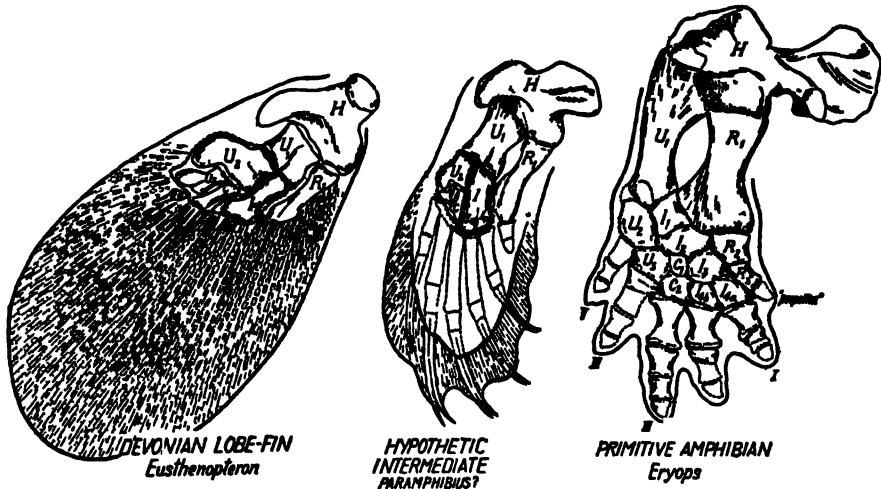


FIG. 12. SUPPOSED TRANSFORMATION OF PECTORAL PADDLE OF DEVONIAN LOBE-FIN INTO PRIMITIVE CHEIROPTERYGIUM OF AMPHIBIAN, BY ANISOMERISM AND SECONDARY POLYISOMERISM

sacral ribs, thus indirectly transmitting their thrusts to the column. The marked and persistent anisomerism of the pectoral and pelvic girdles is thus readily understandable in the light of the functional history of these elements. Nevertheless, a secondary tendency toward polyisomerism very early asserted itself, in that, especially among the Permian reptiles, each half of both pectoral and pelvic girdles came to acquire a triradial suture centering respectively in the glenoid and acetabular depressions and dividing each

changed into a paddle with a movable wrist-like base. In the fan-like paddles of the early crossopterygians (Fig. 12) one set of rods (H, U₁, U₂, U₃, U₄) became the functional axis and one member (H) of this set gave rise to the humerus or single proximal piece. When the paddle was bent sharply upon itself in pushing the body on the mud, anisomeric increase of the proximal elements took place together with some secondary polyisomerism in the elements that were to become the carpals. A similar history in the pel-

vic limb resulted in the anisomerous proximal elements and the polyisomerous extremities.

In the earliest tetrapods each of the elements of the primitive hind foot has the somewhat deceptive appearance of complete homology with the corresponding piece of the fore foot; but it is more than likely that this is largely due to intersegmental polyisomerism.

An even more complete homodynamism and polyisomerism is developed secondarily in the pectoral and pelvic paddles of typical plesiosaurs (Fig. 11).

The fore and hind limbs of birds have attained a high degree of anisomerism with little or no tendency toward secondary or tertiary polyisomerism. The skeleton of the pectoral limbs of humming-birds, for example, is excessively different in function, in general appearance and in detail from that of their pelvic limbs. The same is even more conspicuous in the penguins, where pectoral and pelvic limbs are used, although in very different ways, in propulsion through the water and on land. And yet the remote common ancestors of all birds were primitive lizard-like reptiles with similar but secondarily polyisomerous hands and feet. This case suggests that marked regional anisomerism between serially homologous parts is concomitant with equal differences in function and at present I can think of no exceptions to this rule.

CONCLUSIONS

The phenomenon of polyisomerism, whereby adjacent or serially homologous parts of the body are moulded into similar patterns, obviously results from the interaction of many forces, influences and conditions such as the following: the production of similar units of building material by the digestive system, the similar influences upon a row of homolo-

gous parts exerted by serially homologous nerves and blood-vessels, the similar effects upon all the units of the series by specific endocrine products, in stimulating or retarding growth or in changing the physical or chemical properties of any of the component tissues; finally we have to reckon with the similarities that were initiated by forces let loose by the unfolding genes.

In short, "wholeness," "specificity" and "aristogenesis" seem to be names for certain aspects of the behavior of living kaleidoscopes that slowly evolve through the ages: the little pieces ("aristogenes") that go to make up the patterns are the small units that are budded off from some rhythmically growing organ like the dental lamina; the patterns are determined in part by the primary symmetries and asymmetries of the fertilized egg, in part by secondary symmetries and asymmetries produced, for example, by the recurrent invagination of the ectoderm and the mesoderm so as to form dental caps and tooth germs; or by nodal retardation of growth in a rapidly growing strip, as in the notches and folds of rodent teeth; finally, patterns are produced by the recurrent interference between polyisomerism and its opposite, anisomerism.

As to the occasional recurrent alternation of polyisomerism and anisomerism, let us consider the long line of vertebrates that culminated in the existing narwhal. In the remote reptilian ancestors of the mammals the dentition was at first strongly polyisomerous; this we may call primary polyisomerism. In the higher cynodonts this condition began to give way to a moderate degree of anisomerism, which was progressive up to the time of the earliest creodonts; this may be called the first cycle of anisomerism. In the ancestors of the hyaenodonts the dentition as a whole was anisomerous but the upper

molars were becoming secondarily polyisomeric, through the emphasis of their metastyle shears and the reduction of their protocones. Traces of this condition are still visible in the earliest archæocetes, but by the time we reach the squalodonts the teeth have begun to multiply and to be much simplified and polyisomeric, a tendency which culminates in the dolphins. Here is the phase of secondary polyisomerism. In the immediate ancestors of the narwhal one pair of these similar teeth began to enlarge; this movement culminated in the excessively anisomeric stage of the narwhal, which has in the adult but a single tooth left in the form of a huge spirally wound straight tusk. Thus we have secondary anisomerism of an extreme type. The next stage would probably be loss of all teeth (negative anisomerism).

The usefulness of polyisomerism or reduplication is that it has enabled the same function to be performed by many different units, so that the necessary work could be distributed among many; thus a massive result could be achieved by mass action of small units multiplied by time. As an example we may cite the amazing achievement of the minute teeth of the radula of certain gastropods in boring through the thickest part of the shell of a clam, or the powerful mass action of the tube-feet of a starfish in pulling open the shell of an oyster.

On the other hand, anisomerism, or the inequalization of parts, resulting from the overgrowth of one part of a polyisomeric series, has proved useful under the following conditions: (a) when the enlarged anisomeric parts have been compelled to bear the brunt of attack, as in the canine teeth of the sabre-tooth tiger, or when they serve as a shield, as in the plates of

the carapace of the tortoises; (b) when the enlarged parts serve as a fulcrum, anchor or stay for adjacent parts, as in the coalesced anterior cervical vertebrae that support the immense head shield of ceratopsian dinosaurs, or as in the enlarged sacral ribs that receive the thrusts from the pelvic limbs; (c) when adjacent pieces of an originally polyisomeric series perform narrowly delimited parts of some complex function, as in the several parts of the atlas-axis complex of man.

Thus the presence of polyisomeric parts implies mass action, the presence of anisomerism implies inequality of stresses, highly differentiated functions.

In all Metazoa polyisomerism, or the formation of numerous small unit organs of the same type, is the next step above cell division and the differentiation of the primary germ layers. The quality of specificity or individuality becomes manifest in each case of polyisomerism at earlier or later stages of ontogeny. Polyisomerism, either as between organs or as between the smaller units that compose them, is a universal property of living things; it is the specificity of the polyisomerism that remains to be explained. Here from a historical point of view we emphasize the divergent, cumulative compound-interest-bearing effect of an infinite number of small conditioning factors operating on divergent hereditary lines through geologic time.

In general the nature of protoplasm is such that a separated part tends to assume the form of the parent mass, hence polyisomerism is a result of an inherent property of protoplasm. On the other hand, anisomerism, or hereditary divergence, arises when the forces of polyisomerism are unevenly distributed so that one part grows or evolves faster than its neighbors.

LIST OF LITERATURE

- ABEL, O. 1920. Lehrbuch der Paläozoologie., Gustav Fischer. *Jena*. [Pelmatozoa, pp. 280, 281.]
- BATESON, WILLIAM. 1894. Materials for the Study of Variation Treated with Especial Regard to Discontinuity in the Origin of Species. Macmillan and Co. *London*.
- . 1914. Address before the British Association for the Advancement of Science. *Science*, N.S., 40, p. 294.
- BERRY, EDWARD W. 1929. Paleontology. McGraw-Hill Book Company. *New York*.
- BRYANT, WILLIAM L. 1919. On the structure of *Eusthenopteron*. *Bull. Buffalo Soc. Nat. Sci.*, 13, No. 1.
- DEAN, BASHFORD. 1908. Accidental resemblance among animals. A chapter in un-natural history. *Popular Science Monthly*, 72, pp. 304-312.
- GADOW, HANS, and ABBOT, E. C. 1895. On the evolution of the vertebral column of fishes. *Philos. Trans. Roy. Soc.*, 186 (B), pp. 163-221.
- DELAGE, YVES, and HÉROUARD, EDGARD. 1898. *Traité de Zoologie Concrète*. T. 8. Les Procordés. Schleicher Frères. *Paris*.
- GASKELL, W. H. 1895. The origin of the vertebrates. *Proc. Cambridge Philos. Soc.*, 9, Part 1, pp. 19-47.
- GISLÉN, TORSTEN. 1930. Affinities between the Echinodermata, Enteropneusta, and Chordonia. *Zool. Bidrag f. Uppsala*, 12, pp. 199-304.
- GOODRICH, E. S. 1909. Vertebrata Craniata (First Fascicle: Cyclostomes and Fishes). In *A Treatise on Zoology* [Ed. Sir Ray Lankester], Part IX.
- . 1930. Studies on the Structure and Development of Vertebrates. Macmillan and Co. *London*. [Vertebral column of Tetrapoda, pp. 45-70.]
- GREGORY, WILLIAM K. 1934. Polyisomerism and anisomerism in cranial and dental evolution among vertebrates. *Proc. Nat. Acad. Sci.*, 20, No. 1, pp. 1-9.
- HASSE, JOHANN CARL FRANZ. 1879-1885. *Das natürliche System der Elasmobranchier auf Grundlage des Baues und der Entwicklung ihrer Wirbelsäule. Eine morphologische und paläontologische Studie*. *Jena*.
- HEILMANN, GERHARD. 1927. *The Origin of Birds*. D. Appleton and Co. *New York*.
- LANG, ARNOLD. 1891-1896. *Textbook of Comparative Anatomy*. Vols. 1, 2. Trans. by Henry and Matilda Bernard. Macmillan and Company.
- OSBORN, HENRY FAIRFIELD. 1925. The origin of species. II.—Distinctions between rectigradations and allometrons. *Proc. Nat. Acad. Sci.*, 11, No. 12, pp. 749-752.
- . 1929. The Titanotheres of Ancient Wyoming, Dakota and Nebraska. *Monogr. 55, U. S. Geol. Surv.* Vols. 1, 2.
- . 1933. Aristogénèse, le nouveau principe inductif d'évolution biomécanique. *Revue gén. d. Sci.*, 44, Nos. 17, 18, pp. 495-505.
- PATTEN, WILLIAM. 1912. *The Evolution of the Vertebrates and Their Kin*. *Philadelphia*.
- RITTER, WILLIAM E. 1932. Why Aristotle invented the word entelechia. *Quart. Rev. Biol.*, 7, No. 4, pp. 377-404.
- ROMER, A. S., and F. BYRNE. 1931. The Pes of *Diadectes*: Notes on the Primitive Tetrapod Limb. *Palaeobiologica*, 4, pp. 25-48.
- . 1933. *Vertebrate Paleontology*. University of Chicago Press.
- STENBLOM, ERIK A. SON. 1927. The Downtonian and Devonian Vertebrates of Spitsbergen. Part 1. Family Cephalaspidae. A. Text. B. Plates. *Skrifter om Svalbard og Nordishavet*. No. 12. *Oslo*. [Kiaeraspis, pls. 49-58.]
- STÖRMER, LEIF. 1933. Are the trilobites related to the arachnids? *Amer. Journ. Sci.*, (5), 26, No. 152, pp. 147-157.
- WATSON, D. M. S. 1925. Croonian Lecture: The Evolution and Origin of the Amphibia. *Philos. Trans. Roy. Soc. London*, (B), 214, pp. 189-257.



SIGNIFICANCE OF THE BIOTIC COMMUNITY IN ECOLOGICAL STUDIES

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INTRODUCTION

DURING the eighteenth and nineteenth centuries, many leading biologists sought a knowledge of nature in the open. These were the days of famous naturalists, systematists, and faunal and floral geographers. Toward the end of the nineteenth century a group of gifted laboratory workers came to occupy the center of the stage, and the emphasis on field work unfortunately lessened somewhat. In these days of the twentieth century a renewed interest in Nature out-of-doors is evident. The proponents of "scientific natural history," or ecology, are making ever more valuable contributions. Their work is commending itself increasingly to the general biological public, and their numbers and influence are steadily augmenting. A few praiseworthy efforts have been made, also, toward the coördination of field and laboratory investigations.

Ecologists, like other biologists, have usually entered their chosen field through specialized work either on animals or plants. As studies proceed of the structure and relationships of *communities* of living organisms in the field, more and more workers are appreciating the vital character of the interdependencies between plants and animals. It is being realized that investigations of "animal" ecology and of "plant" ecology assume their proper status only in the great coördinating field of bio-ecology (or simply, ecology), the study of all living organisms,

plant and animal, as related to their environment.

THE BIOTIC COMMUNITY AND THE ECOLOGISTS

Seemingly the trend among ecologists is increasingly toward the bio-ecological point of view. In an outstanding paper which summarizes the situation, Phillips (1931) presents a résumé of the principal divergent views regarding the relations of plants and animals in natural communities. Phillips points out that by one group of workers, including most plant ecologists, animals are regarded as biotic factors external to the plant community. By another group, including many animal ecologists, plants are regarded as a portion of the habitats in which the animal communities live. By a third group, of which Phillips himself is a distinguished representative, plants and animals are viewed as interrelated, co-acting constituents of an integrated biotic community.

Under the first group, including ecologists who regard animals as biotic factors external to the plant community, Phillips discusses the work of Warming, Flahaut and Schröter, Tansley, Yapp, Farrow, Watt and Osborn. As representing the smaller group of animal ecologists who believe that plants should be considered as a portion of the habitat, i.e., not as members of the community, Phillips suggests Klugh, Pearse, Chapman, Elton and Adams.

We next consider those who regard plants and animals as interrelated, co-acting constituents of an integrated biotic community. Möbius, who in 1877 sug-

gested the terms *Biocönose* or *Lebensgemeinschaft*, is cited as a pioneer in the concept that plants and animals together may form a biotic community in possession of a certain definite territory.

In his discerning investigations of the lake as a microcosm, Forbes (1887, p. 77) referred to the sensibility of the organic complex in the lake. He pointed out that whatever affects any species belonging to this complex must speedily have its influence on the whole assemblage. It is impossible, he said, to study any form completely, out of relation to the other forms. It is necessary to make a comprehensive survey of the whole before one can acquire a satisfactory understanding of any part. Forbes was interested in studying the natural interactions by which the mere collocation of plants and animals has been organized as a settled and prosperous community, as he put it. The concept of the biotic community was clearly in his mind, though he gave it no name.

Merriam (1890, p. 27) called pointed attention to the coincidence in the limitation of the life areas or zones on San Francisco Mountain. In a later paper (1892, pp. 7-8) he gave a list of fifty-six authors who have proposed faunal and floral regions or zones for North America. Of the fifty-six, but one—Dr. Merriam himself—based his proposed bio-geographical divisions on both animals and plants.

The point of view of the botanists who had gone farthest along the road toward bio-ecology, was expressed by Clements (1905, p. 16) who noted that animal formations, although often poorly defined, do exist, and frequently coincide with plant formations. In his *Plant Indicators* (1920, p. 38) Clements referred to the growing recognition of the community as consisting of both plants and animals.

Vestal (1913, p. 13; 1914, p. 444) gave

still clearer recognition to the general proposition that the animals and plants in a given terrestrial environment are intimately related.

In 1915 (p. 20) Shelford, discussing the principles and problems of ecology as illustrated by animals, noted that agreement between animal communities and plant communities is evidently the rule.

The same year Adams (1915, p. 157) referred to the vast number of smaller animal, or biotic communities in the forest, but seems to have had in mind animals only in his thought of the biotic community.

Both Yapp (1922, p. 11) and Tansley (1923, p. 166) have written of the grouping of plants and animals together into communities. But in 1929 (p. 680) Tansley believed it essential to consider the plant communities separately, and to regard animal factors as external to them.

During the last fifteen years, the concept of the biotic community as an integrated unit assemblage made up of both plant and animal constituents has been growing apace. We cannot stop to examine all the evidence and opinion; but we wish to point out the views of a few more of the active workers in the field to indicate the direction of the trend.

Clements has proposed the term *biome* to embrace both plants and animals in a common community of living things. We thus have the terms *vegetation* or *flora*, standing for the plants; *fauna* or "*animal life*" for animals; and *biome*, a short and appropriate name for the biotic community embracing both plants and animals.

Beginning about 1918, a group of workers, largely in the western and southwestern United States, have been giving special attention to the bio-ecology of the grassland formation and desert, with special reference to insects, birds, and

rodents. Reference to some of these studies has been made by Clements and Taylor (1923).

In 1925 (p. 21) Weese expressed the opinion that "The animal communities of a given region cannot be considered, logically, separately from the plant communities."

Studies of birds, mammals, and plants in many places in the west, as related to farm, forest, and grazing ranges, have unmistakably indicated the interdependence of plants and animals. Relatively thorough studies have been made in plant ecology, but adequate provision for work on animals has not been made. In 1925 (pp. 390-393) the present writer noted the lack of attention to zoocology, pointing out that the problems of culture, maintenance and administration of agriculture in general, and forage and forest in particular, directly involve animals as well as plants. In a later paper (1927, p. 281) he expressed the opinion that a thorough-going conception of the bio-ecological nature of forest problems, of grazing problems, and of most other agricultural problems would lead to more certain and satisfactory solutions.

In 1926 Phillips emphasized the important interrelations between animals and plants, especially as shown by the services of animals in dispersing the fruits and seeds of forest species. In 1931 (p. 14) he wrote:

Throughout the . . . account I have given of the inter-relations of plants and animals in the Knysna forests, runs the golden theme that the whole community of life is a beautifully integrated series of factors, responses, reactions, and co-actions. To remove the animals would result probably in dire results for the plants, to fail to include them in the concept of the community cuts across logic.

Allee (1926, pp. 462-467), in his discussion of the distribution of animals in a tropical rain-forest, evidently assumed the

existence of biotic communities. In another place, discussing needed lines of investigation in American entomology, Allee (1927, p. 439) referred to insect communities as abstractions, pointing out that really there are only biotic communities, i.e., groups of plants and animals which are more or less closely integrated into a community system. Still more recently Allee (1934) has used the term geo-bio-ecology, to indicate the complex relations of living things with each other and with their non-living environment.

In his comparison of the animal communities of coniferous and deciduous forests, Blake (1926, p. 90) assumed the interrelationship of plant and animal life.

Cooper (1926, p. 396) expressed the opinion that the strictly logical procedure would be to include the animal life with the vegetation in our communities.

In a clear-headed review of Pearse's *Animal Ecology*, Jones (1926, p. 504) expressed the view that the classification that ecologists must eventually settle upon will be one in which both plants and animals are included in the same communities.

THE BACKGROUND OF THE BIOTIC COMMUNITY

Like the individual plant or animal, the biotic community is the product of environment (See Breazeale, 1927, pp. 404-405). The organized assemblage of species must be adapted to its surroundings or it would not be here. The interdependencies between plants and animals are as much the products of adaptation as are the relations between the individual and its inorganic environment.

The assumption that "plant" life appeared first on earth, being followed later by animal life, requires modification. Little is known about the primal forms, but present-day observation and experience support the hypothesis that plant-like and

animal-like forms have existed together as long as life has been in the world. The earliest organisms may well have combined plant and animal characteristics. Haeckel years ago (1904, p. 205) placed the most primitive living things in the protist kingdom. There are several simple creatures still in existence that are difficult to classify as belonging to either the plant or animal kingdoms.

If we are to make our assumptions on the basis of observation, experience, and experiment, must we not conclude that the biotic community reaches far back in time; that the protists may perhaps be regarded as individuals partaking somewhat of the characteristics of both plants and animals; that as the plant and animal kingdoms diverged their members, respectively, lived in close association, and were interdependent? These formed the earliest true biotic communities.

THE BIOTIC COMMUNITY MAY BE COMPARED TO AN ORGANISM

When the manifest and inevitable interdependencies between plants and animals are considered it is increasingly clear that it is the *biotic community*, and neither the animal community alone, nor the plant community by itself, that is the real entity. More than fifty years ago Semper (1881, pp. 29, 32-33) likened the animal community to an organism. It is well known that Clements (1905, p. 199) referred to the plant formation as an organism.

That the individual organism and its environment may be regarded as the internal and external portions of a single system of material and energy was recently asserted by Livingston (1929, p. 1107). Even more accurately, it seems to the present writer, the *biotic community* and its environment may be regarded as the internal and external portions of a single system of material and energy.

One of the outstanding features of the Matamek conference on biological cycles, according to Huntington (1931, p. 234) was the frequency with which one member or another emphasized the fact that in spite of minor differences, the general reactions of man, animals, and plants are essentially the same. Why not? All are parts of a great biotic community.

Brehmer (1927, pp. 247-250) concluded that the individual organism is a vast community in a high state of coöperative activity. In the biotic community we recognize a still vaster community than that of any individual animal or plant, and indeed, embracing all animals and plants in a particular place. Like the individual, the biotic community is also in a high state of coöperative activity.

There are three important ways to test the thesis: That the biotic community rather than the animal community alone, or the plant community alone, is the true unit, corresponding in its development to a complex organism.

(1) Trace the interrelationships between the component plant and animal species of the biotic community. If the interrelationships are vital rather than incidental our thesis will be maintained.

(2) Note what happens when a single species of plant or animal is disturbed or eliminated. If such disturbance affects only the species involved, or, if a plant, only other plants, or, if an animal, only other animals, our thesis will be militated against. If, on the other hand, far-reaching effects permeate the entire community, influencing many plants and animals, it will be upheld.

(3) Study the results following introduction of a foreign species of plant or animal. Are only plants affected by the introduction of a foreign plant, and only animals by the bringing in of a foreign animal, or is the entire biota influenced?

We scarcely need to do more than state these questions before the answers are apparent.

(1) The interrelationships between the members, plants and animals, of a biotic community are vital, not incidental. Selected examples are given in a later section of this paper under the heading "Some Interdependencies between Plants and Animals."

(2) Disturbance of a single important species of plant or animal is likely to have far-reaching effects on many or all other plants and animals. Cut a forest and plants and animals generally, from the highest inhabited forest stratum to the lowest depths of the forest soil where organisms occur, are undoubtedly affected. The entire original biotic community is shaken to its foundations and, to a great extent, eliminated and replaced. Succession begins anew.

Overgraze a stock range and similar far-reaching results may ensue. The climax grasses tend to disappear, and various less valuable species become conspicuous. The surface of the ground is less well protected, and erosion and run-off are accelerated. The animal inhabitants, from insects to rodents, tend to be altered.

Release of an overgrazed range from ultra heavy pressure exercises like profound effects, whether the pressure has come from domestic livestock or native grazing species like the buffalo. Many forms of vegetation previously suppressed are now released, and as they change, so do many of the insects, birds, and mammals. Our studies show that these changes may be of considerable significance.

Tansley (1923, p. 169) has pointed out that there is abundant evidence that the destruction of carnivorous birds (hawks, jays, etc.) and small animals (stoats,

weasels, etc.) by game keepers in England, handicaps or destroys the chances of tree reproduction in many English forests.

But elimination of important plants or animals is not the only kind of modification that exercises far-reaching effects on a biota. Abnormal increases in the numbers of particular species may have an influence also. As Hermann Krauch (U. S. Forest Service) pointed out to the writer, these abnormal increases themselves are due to a disturbance of controlling factors. The plagues that occurred at intervals in Egypt, and from which at some time or other few countries have been free, are notorious in their influence on the entire biotic community. Abnormal increase of the deer on the Kaibab National Forest in northern Arizona threatened the very existence of important elements of their forest habitat.

(3) It is clear to the most superficial observer that introduction of exotic species, whether of plants or animals, may have far-reaching effects on the entire biota.

Some of the introductions in America we number among our most serious pests. Consider the numerous pestiferous weeds, the boll weevil in the United States; the blister rust, the corn borer, the Norway rat, all introduced species, and all extremely serious economically, affecting the status of many plants and animals, including man. The prickly pear in Australia, the rabbit in England and Australia, the Colorado potato beetle in Europe, the American gray squirrel in England, the American muskrat in England and in western Europe, the mongoose in Jamaica, come to mind as additional examples. Perhaps the chief difficulty in connection with introductions of this character is that the natural controls are not introduced along with the troublesome

species, or that the total environment in the new area simply does not suffice to keep the newcomers in their place.

Agriculture, with its beneficial introductions, as of the potato and numerous grains, fruits, and vegetables, and of domestic animals, has almost completely altered the natural biota over large areas.

It is perhaps obvious without going into further detail, that introductions of foreign plants have had a far-reaching influence on both plants and animals; and that the introductions of animals have had similarly comprehensive consequences. In many instances the effects of introductions of plants apparently have been more profoundly registered on animals than on plants; and the effects of introduction of some foreign animal have perhaps shown up more conspicuously among the plants than the animals of the region where it was introduced.

There is a question, in the mind of the writer, how far we are justified in applying the concept "individual." The individual organism is sometimes thought of as one capable of independent existence. But few or no organisms are capable of independent existence. They depend utterly, in final analysis, on other individuals or species. Certain termites perish in the absence of their symbiont protozoa. Animals would quickly disappear were it not for the plants on which they feed. Apparently there is little rugged individualism in nature. Plant associations or animal associations are abstractions, important but incomplete. Apparently the biotic community, the interacting, interrelated, interdependent, loosely or closely organized cooperative commonwealth of plants and animals in their environment, is more nearly an individual organism than any of its parts. Seemingly, the relations between organisms, and between the organisms and their surroundings, are so close and obligatory that the organic-inorganic complex complete is the real unit.

THE BIOTIC COMMUNITY—SOMETHING MORE THAN THE SUM OF ITS COMPONENTS?

It is a commonplace that a chemical element, such as hydrogen, when isolated, possesses certain properties. When

combined with oxygen to form water, however, the situation is seemingly quite different. The compound has characteristics one would never suspect from a study of its elements.

In much the same way an individual organism or a single species possesses certain characteristics; but when joined with its fellows in a biotic community other qualities, often completely unsuspected, emerge. As a matter of fact, as Wheeler (1928, p. 38) has pointed out, there is something fundamentally social in all organisms, and all organisms are at least implicated in some biocenose, or, as we would say, biotic community. There is no such thing as a hermit organism.

We can never learn all we need to know about living things by a study of individuals or even of species. Knowledge of the relations in which species stand to each other, information regarding their organization into biotic communities, are essential to an adequate understanding of nature.

SOME INTERDEPENDENCIES BETWEEN PLANTS AND ANIMALS

The juniper in parts of the Southwestern United States is apparently dependent for its distribution to a considerable degree on the sheep. (Information on sheep-juniper relations furnished by C. K. Cooperrider, U. S. Forest Service.) The seeds of the juniper pass through the sheep and are distributed in areas previously not occupied (recently at least) by the juniper. The sheep also tend to weaken the grassy and herbaceous growth of the region, thus lessening its ability to compete with the juniper, and paving the way for the establishment of the aspiring juniper seedling.

On the Santa Rita Experimental Range, near Tucson, Arizona, as on all grassy range country, the destiny of the herds of livestock is dependent on the welfare of

the grasses on which they principally feed. The grasses in turn, depend for their own future status on the livestock. If stocking is too heavy, the climax perennial grama grasses are replaced by the annual "sixweeks" gramas and needle grasses, as well as a variety of weeds. Even the native rodents (especially the jack rabbits and banner-tailed kangaroo rats) are concerned here. Where, as a result of over-grazing, the vegetation is having a struggle to maintain itself, rodents alone may be sufficiently influential to turn the tide back from the more palatable and valuable climax stages to the relatively worthless secondary stages of vegetation.

On an overgrazed range on the Wichita National Game Preserve, Weese found certain insects many times as numerous as in the climax stage of vegetation. Rodents are notably more numerous in the mesa and semi-desert types on the Santa Rita Experimental Range than in the better-grassed foothill types. There is accumulating evidence that certain rodents and insects may sometimes be both a cause and an effect of over-grazing. A cause, for where they are numerous they do cut down the vegetation, and tend to accentuate the overgrazed condition, especially during periods of extreme drought. An effect, for where, for any reason, over-grazing has developed, and the secondary herbs and grasses come in, certain insects and rodents also tend to increase.

Reference has already been made to the effects of forest removal. Where a forest is clearcut, and thereby the dominant species of plants (the timber) removed, there obviously follows a profound change affecting every other plant and animal in the area, as well as the physical and chemical factors of the site. Even the microclimates of the soil and the surface strata of atmosphere are modified.

In parts of Africa man may be affected by the highly fatal disease, sleeping sickness, the germ of which, a protozoan, is transmitted by an insect, the tsetse fly. But this is not the whole story. The tsetse fly is abundant where there is "bush" or forest; in fact, clearing the vegetation around the native villages is receiving attention as a control measure. Phillips (1930, pp. 217-219) gives an account of a deciduous scrub, of which the genera *Grewia*, *Pseudoprosopis*, *Bussea* and other plants are members. This scrub community harbors few game animals and appears to form a barrier to the advance of the tsetse. The chain of causes and effects in relation to sleeping sickness again cuts across the bounds of the plant and animal associations and is clearly seen to be biologic in its nature.

Darwin (1898, p. 66) has pointed out that the dependency of one organic being on another lies generally between things remote in the scale of nature. This generalization is illustrated in every biotic community and is a strong argument for the naturalness and validity of the biotic community concept. The flowering plant depends on the bee. Growing vegetation depends on the soil organisms, probably always including animals, which keep the complex structure of the soil in suitable condition for the support of vegetation. The deer depends on the browse plants of its habitat. The bark beetle depends on its forest tree host. The mourning dove requires the seeds produced by numerous herbs. The carnivores depend on the herbivores, which themselves depend on a variety of plants, which, frequently or nearly always, depend on soil animals, and so on in a great physical-chemical-biotic circle of relationships. Man himself, in his food and shelter requirements, illustrates a hundred times a day his

dependence on things remote from him in the scale of nature, mostly plants.

FUNDAMENTAL INTERDEPENDENCIES BETWEEN ANIMALS AND PLANTS ARE USUALLY MORE OBLIGATORY AND INEVITABLE THAN THOSE BETWEEN PLANTS ALONE OR BETWEEN ANIMALS ALONE

Although in numerous instances insects are parasitic on animals, and predatory animals dependent on plant-feeding creatures, nevertheless many or most animals are obviously more dependent on certain *plants* of their environment than they are on any other animals, for food, or for shelter, or both. It is just as obvious that many plants are more dependent on certain animals than they are on any other plants. We have only to recall the dependence of the flowering plant on the bee or moth or bird, which cross-pollinates it, to see how the matter works out in a considerable number of cases. Pickens (1929) has recently shown that in California the white sage (*Ramona polystachya*), which is pollinated by a large bee (*Xylocopa*), nevertheless occurs in some localities where this species of bee is absent. In such localities, the Costa hummingbird (*Calypte costa*) functions in the transfer of the pollen.

The relation of the *Pronuba* moth to the Spanish bayonet (Genus *Yucca*) of the Southwestern deserts has been made known by Riley and his associates (see Folsom, 1922, p. 222). Jepson (1910, pp. 169-170) has summarized the situation as follows: The flowers are incapable of self-pollination. Each species of *Yucca* is dependent on a particular species of moth.

"The female *Pronuba* works by night, collecting the pollen from the anthers and rolling it into a little ball; she then flies to the flower of another plant, deposits her egg in the ovary, and then in a manner which seems to indicate that her actions are full of purpose and deliberation climbs to the style and thrusts the pollen ball far down the stigmatic tube.

The larva destroys about a dozen seeds, but even if several larvae develop, many perfect seeds are left."

Literally thousands of plant-animal relationships, as obligatory as the examples given, are well known to science.

A plant attacked by certain insect pests is or may be vitally dependent on parasitic enemies of the pests and on insectivorous reptiles, mammals, and birds.

An instance of interdependence is that of the carnivorous plants, including the sundew (*Drosera*) and its associates in the Droseraceae (also *Pinguicula* and *Nepenthes*), which capture, digest and absorb animal matter; and *Utricularia* and its close allies, which, while they cannot digest animal matter, nevertheless absorb the products of decay of the animals they capture. For a full discussion of these species, consult Darwin (1889).

The citrus industry in southern California is to a large degree dependent on a certain lady-bird for its very existence, for the cottony cushion scale, otherwise, would limit or perhaps wipe out the oranges, lemons, and grapefruit. The lady-bird is so effective an enemy of the scale, however, that the ravages of the latter are negligible.

Another California industry of large proportions, namely, the culture of the Smyrna fig, is dependent on a plant-animal relationship. The superior flavor of the Smyrna fig, explains Folsom (1922, p. 428), results from the presence of the ripe seeds which result from fertilization. This process is accomplished by a tiny fly of the genus *Blastophaga*, which develops in the gall-like flowers of the wild fig. The winged female, emerging from the gall covered with pollen, enters the young flowers of the Smyrna fig to lay its eggs, and in the process pollinizes them.

The welfare of plants is closely related to soil conditions, and soil conditions are intimately linked up with the number of

earthworms, burrowing rodents, ants, and other soil forms, large, small, and smaller.

Many plants are more or less dependent on fruit and seed-eating species of animals for planting their seeds, and particularly for the extension of their ranges.

Plants in general are somewhat dependent on animals for the very carbon dioxide which they require for their photosynthetic processes, although this relationship is doubtless of slight importance.

Willis (1922, p. 203) referred to animals as a function of plants, indicating his appreciation of the intimate interrelationships of the two kingdoms.

Obviously all the herbivorous animals are dependent on their food plants, probably more closely, in at least the vast majority of cases, than on any other animals. Animals requiring certain plants for shelter are also more dependent on such species of a different kingdom than on any other animals. Even carnivorous animals are indirectly dependent on plants.

There would be no need to labor a point that is a biological commonplace were it not that much biological work, involving both theory and practice, has been done on the theory that plants and plant communities are separate and independent from animals and animal communities.

GRADES OF BIOTIC COMMUNITIES

Biotic communities may be graded, according to their size and complexity. One may give attention to the biotic community in a fence-post, or in the intestine of a cat, or under a stone in a running stream, or in an ant mound, or in the nest of a mouse or a bird.

Some of the lesser biotic communities are of surpassing interest. Take the communities in such places as the dens of the banner-tailed kangaroo rat in the arid Southwestern United States. These dens are the world of action for a number of insects and

soil organisms, a refuge and shelter for several reptiles and even mammals. Organisms are relatively abundant in the worked earth of the kangaroo-rat den, while relatively rare outside. A number of animals habitually and characteristically use and take refuge in the dens. This is true of certain snakes, especially gopher snakes and racers. It is also true of Gila monsters, and a number of other lizards, including the delicate banded gecko (*Coleonyx variegatus*). There is thus a rich community represented in these dens, including members of widely diverse animal groups, as well as doubtless many bacteria and other plants. All depend for food on their animal confrères, or on the accessible vegetation or animal life within or in the neighborhood of the den, or on decomposition products from some of these other sources.

On the other hand one may enlarge his view and regard the biotic community of a particular stream-side or pasture, or pond, or bay, or field border, or wood lot. Or he may still further expand his vision to embrace the biotic community of some vast forested area, or extended grazing range, or a particular life-zone, region, or realm, or say, of a continent or the ocean itself. Biotic communities vary in size and complexity from the circumscribed assemblages in closely restricted habitats to the largest biotic community, comprising all living forms on earth.

Conceived in this manner, one should have no particular difficulty with the problem of wide-ranging forms of animals, as the mountain lion (*Felis concolor* and related forms), badger (*Taxidea taxus*), and others, which occur rather indifferently in the hot, low country along the Rio Grande and Lower Colorado River, and in the cold zones of the Sierra Nevada of California and the Mogollons of Arizona and New Mexico. These mammals and a number of plants also, occur as members of a more extended and extensive biotic community than the others. Longstaff (1932), after an ecological reconnoissance in West Greenland, wrote: "It is striking how little the animals fall into definite communities and

how few habitats have exclusive species." The wide-ranging species are ecologically adaptable. We must fit our biotic communities to the organisms composing them, and not the other way around!

Man himself is a significant example of a wide-ranging form. One way or another, by carrying special equipment for securing necessary food and shelter, he is able to adapt himself to a wider range of environments than any other creature. He is at present the most prominent and in many respects the most powerful member of the world biotic community. His risks, opportunities, and responsibilities are correspondingly great.

It is probably true that no biotic communities in the world are "closed" in the sense that they are completely cut off one from another. Life exists in the similitude of a vast interrelated network, terrestrial and subterranean, aerial and aquatic. Any biotic community which is less than the world community is at most an incomplete and somewhat artificial thing, with arbitrary lines drawn for convenience in treatment. Ecology, in usually dealing arbitrarily with its material for study, is like every other science. All we can do, with our finite capacities, is to investigate and explore as best we may the tiny corner of the universe to which we have immediate access. But our arbitrary divisions should not blind us to the essential unity of all nature.

ANNUAL AND SEASONAL VARIATIONS IN THE MAKEUP OF BIOTIC COMMUNITIES

The species composition of the biotic community, especially on the animal side, is variable according to the season of the year. (Phenomena of biotic succession are of course not here discussed.) At one season, for example, a host of migratory birds, or perhaps of insects, may quite markedly alter the aspect of the com-

munity in any given place. While it is quite proper to include wide-ranging and migratory forms in the communities where they are found at any time of year, the basic structure of the biotic community is probably builded chiefly by the species that breed or reside permanently therein. Thus the western robin (*Turdus migratorius propinquus*) may be a member of the biotic community of willow-bordered bottoms at Tucson, Arizona, in winter, though its ecologic importance may not be very great there. It is a much more important member of the streamside subdivision of the yellow pine biotic community of the nearby Santa Catalina Mountains in summer. For there it is a breeding bird. It is true that in regions like the Gulf coast, where migrant birds concentrate in great numbers in winter, these non-breeders may as it were set the pace for the biotic community the year through. In general, however, the resident or breeding substratum of animals and plants is of fundamental significance.

The influx at certain seasons of the year of wide-ranging or migratory birds or mammals is somewhat analogous to seasonal aspects which we observe in the flora.

Plants avoid or escape unfavorable seasons by becoming quiescent, either as seeds, spores, bulbs or other underground parts, or sometimes as resting stages both above and below ground. Some animals, as insects, amphibians, reptiles, and hibernating mammals also avoid inimical conditions by becoming quiescent. Most warm-blooded species cannot do this, but must migrate. From our standpoint, therefore, the processes are strictly analogous, as both aim to secure the same thing, namely, survival in a particular geographic area where otherwise survival would be impossible.

In the southern Arizona region, there are no less than 122 annual plants that appear above ground only in winter (Thornber, 1909, p. 104). Among these are such forms as *Amsinckia intermedia*,

Erodium texanum, *Gilia* (several species), *Lupinus leptophyllus*, *Mentzelia aspera*, *Phacelia distans*, *Oenothera* (several species), *Avena fatua*, and numerous others. There is a considerable list, in the same region, of winter birds, including the western robin, Audubon warbler, ruby-crowned kinglet, American pipit, Gambel sparrow, and Brewer sparrow. Certain plants in the same district grow only under the influence of the summer rains, and a large number of birds appear only during the spring and summer period, when they breed. A number of the reptiles, amphibians, and insects, also, become active in summer only, constituting another phase of a truly seasonal aspect of the biotic community.

Variations occur in the vegetation and the animal life from year to year also. For example, on the Santa Rita Experimental Range, near Tucson, *Eschscholzia mexicana* flowers in profusion during some winters, while in other years only a few plants appear. Similarly, the western robin only seldom appears abundantly in Tucson in winter. The cedar waxwing occurs irregularly also, occasionally becoming quite numerous, while at other times it does not appear at all.

The extreme deserts afford special cases of seasonal and annual variations in biotic communities. Buchanan (1921, pp. 104, 217) in his explorations of Aïr in the southern Sahara region north of Nigeria, found the neighborhood of Takoukout very dry in March at the margin of the bush where it gives way to the desert. In August, after the advent of "rains," a tall rank grass sprang up, the acacias produced leaves, and the Dama gazelles migrated northward into the desert margin to feed on the fresh delicate grasses. Waterfowl also appeared. The country was vastly changed from the open barrenness it possessed in the dry season. Somewhat

similar observations were made by Thomas (1931, p. 220) in the great desert of southern Arabia. Settled life is nowhere possible, because of a lack of pasture. "... good pastures are nowhere perennial and sufficient. Vast tracts of desert are at any one time utterly destitute of herbage, and the abode of death for him who loiters." But certain nomadic tribes do penetrate the remoter central sands in search of grazing following rains. These instances emphasize the fact that the composition of the biotic community is in places highly variable in accordance with climatic and weather conditions. Conditions of soil and climate set the possibilities. More or less fixed is the vegetation present in these desert areas over long periods of time, in the form of spores, seeds, or other dormant plant parts. When the rains come, certain plants appear, and taking advantage of these there appear or move into the country a considerable number of insects, birds, herbivorous animals, flesh-eaters to feed on the herbivores, and even man himself. In such cases the most visible and conspicuous (perhaps sometimes the most important) parts of the biotic community may be its mobile and migratory rather than its fixed portions.

In the semi-desert and some of our desert grassland types in the southern Arizona region we consistently observe this mobility, according to season, of portions of our biotic communities. The summer rains are very irregular. Where they fall, there develops a relatively rich biota. In dry parts of the area, missed by the summer showers, the lands remain bare and seemingly nearly lifeless.

The variable composition of the biotic community according to the season is illustrated not only by the extensive areas mentioned, but in lesser habitats as well. Thus Holmquist (1928, pp. 83-84) has

The program of President Franklin D. Roosevelt and the Congress of the United States (spring 1933) to give work to 250,000 of the unemployed in reforestation affords an opportunity, perhaps of its kind unparalleled in the world's history, for application of ecological information. Inescapably linked with the field problems of the vast reforestation enterprise will be considerations of soil, plants now on the ground, probable effects of insects, rodents, predatory animals, birds, and game species on the seeds or seedlings, status of grazing by domestic stock, and the probable incidence of fires. Every one of these difficult problems is ecological in essence. Indeed, the success of this ambitious and promising project will largely depend on the degree to which its leaders possess the ecological point of view and succeed in getting it applied in practice.

Similarly with wild-life regulation. The conservation agency that gives its attention exclusively to particular game species will, in all probability, expend a great deal of money and effort. It may make a record for aggressive activity—but it is quite likely to fail in permanently improving the game resources of the State. In the past, game species have been repeatedly introduced, at great cost, only to disappear. Instances of wastefulness, due principally to ignorance, are all too numerous in the wild-life field. The scaled quail, native of the arid area about Eagle Pass, Texas, was once liberated at Aberdeen, Washington, where the humidity and rainfall are high. Result, failure. The Chinese quail, a migratory species, has been several times introduced in continental America. Result, failure. The only safe course to follow in wild-life management is to give attention to the entire biotic community in its environment. Conservationists in increased numbers realize that a "wild-life" agency, previous to any proposed introduction of wild species, should find out whether the place proposed to be filled by the species to be introduced is already occupied by a native species. The climatic, soil, and all the complicated plant-animal relation-

ships should be given the closest attention and detailed study. Similar consideration should be given desirable species of game threatened with decrease or even possible extinction. Instead of thinking of protection solely in terms of bag-limit laws, seasons, and predators attention should be given to the entire complex, especially food and shelter. Since the food and shelter will largely come from plants, we again encounter the biotic community head-on. Surpluses of game in some areas have developed as a result of maladministration due to lack of applicable ecologic data. Increased numbers of citizens are realizing that wild life administration should be in the hands of capable trained biologists, and that, to secure the most satisfactory results, such officials must be liberally supported and kept on the task regardless of politics.

A vast area in the United States, indeed more than a billion acres, is devoted to range and pasture. Range management, being concerned with animals (livestock) on the one hand and forage on the other, obviously has to do with a biotic community of tremendous material value. The stock business introduces new species (domestic livestock) into natural biotic communities already often in a delicate balance. The consequences of the "fumble and success" methods of the past have little to recommend them. Frequently they have been disastrous, both to forage, wild life, and livestock. Farsighted range specialists now see that range management must not confine its attention to animal husbandry and strictly forage plants alone, but must consider every phase of the biotic community (natural and artificial) involved, since this is all a part of the essential environment.

A significant sphere in which the bioecological point of view promises improved results is that of watershed ad-

ministration. As a rule engineers of high technical competency are in charge of reclamation and irrigation enterprises. Inflowing streams are carefully measured, the capacity of the storage reservoir closely estimated, the construction of the dam planned to the last detail. The problem of financing the project over a considerable term of years is also elaborately and minutely calculated.

But other things than strictly engineering and financial aspects are involved in the long-time maintenance of reclamation projects. For example, what is the condition of the soil-binding vegetation on the watershed? Is livestock being permitted to overgraze the watershed, thus removing the protective soil cover, promoting accelerated erosion, disastrous flooding, and rapid filling of the reservoir with silt? Who lives on the watershed and what effect will this human population have on the project? What are the rodent, game, and recreational aspects of the watershed? Proper administration of the watershed, on the principle of greatest good to the greatest number, depends on careful weighing of values, taking into account all aspects of the biotic community in its environmental setting. If the engineer-in-charge possesses elasticity of mind and real breadth of vision, well and good. He will call into consultation bio-ecologists and will shape his plans accordingly.

Even the social and economic relations of man himself would vastly benefit from the bringing to bear on his problems of the bio-ecological viewpoint. The present-day tendency to treat sociology on an ecologic basis is sound.

Bio-ecology is responsible for two generalizations of profound import to the welfare of the human race. (1) Man cannot live to himself alone, but must care for the trees and grasses, the animals,

and the world's inorganic resources as well, all of which are so vital to his existence. If man unwisely disturbs his environment he may hurt himself most. (2) Man is a member of the world biotic community and is affected, for better or for worse, by changes taking place in the status of his own or other species or their surroundings anywhere in the world. The implication is that in scientific internationalism lies the hope of the future; that recognition of the essential oneness of man and his total environment is essential; that true progress can be made only by advancing the interest of humanity everywhere.

SUMMARY

Ecologists the world over are recognizing in the biotic community (all the plants and all the animals in a given unit of environment) the true natural unit of organic life rather than the animal community or the plant community alone.

Ecology is the science of biotic communities as related to their environment.

The complex known as the biotic community may be compared to an organism, possessing a beginning, a development, and an end.

Dr. W. B. Bell of the Biological Survey suggests that the final term of a particular biotic community is properly not an "end" but rather the termination of a cycle, that even the life of an individual organism does not normally "end" but flows on unbroken from one generation to the next. This is equally true, of course, of the biotic community.

It should be pointed out that the community that may be compared most adequately to an organism is the biotic rather than the animal community (Semper) or the plant formation (Clements, earlier papers).

Plants and animals are interdependent; indeed, animals are likely to be more dependent on plants than on other animals,

and plants more dependent on animals than on other plants. Systematically, the closest relationships are with the creatures nearest in the line of descent, i.e., an animal is most closely related to some other animal. Ecologically, the closest relationships are likely to be with some species remote in the line of descent, i.e., an animal is most intimately dependent upon a plant, and vice versa.

Biotic communities cannot be rigidly defined or classified. They are of all grades, from the closely circumscribed communities in limited localities, to the world biotic community including all living forms. The problem is not to make living creatures fit any special scheme of biotic communities, but to make the biotic communities conform to living organisms.

Seasonal and annual variations in the biotic community are conspicuous and often important. Groups of organisms which appear in a given biotic community only at certain seasons or in certain years may perhaps best be regarded as intrinsic parts of the biotic community which reach expression only under favorable circumstances.

The concept of the biotic community possesses far-reaching implications in all the enterprises of economic biology, as

forestry, range administration, wild-life management, and agricultural operations generally, not to mention in detail the social sciences.

It is not too much to assert that bringing to bear the bio-ecological point of view offers the best assurance we can have that each unit of area will be so administered as to produce at a maximum and still maintain its capacity to produce. The emphasis placed by bio-ecology on organism and environment as a great unitary system is an inspiring one, and should lead to a more profound insight into many problems in diverse fields of human interest and larger contributions to human welfare.

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LIST OF LITERATURE

- ADAMS, C. C. 1915. An ecological study of prairie and forest invertebrates. *Bull. Ill. State Lab. Nat. Hist.* 11: 33-280.
- ALLER, W. C. 1926. Distribution of animals in a tropical rain-forest with relation to environmental factors. *Ecology*, 7(4): 445-468.
- . 1927. Insect ecology. *Ann. Ent. Soc. Amer.*, 20(4): 439-444.
1934. *Science* (Supp.), 79 (2041): 5.
- BLAKE, I. H. 1926. A comparison of the animal communities of coniferous and deciduous forests. *Ill. Biol. Mon.*, 10(4): 1-148.
- BREAZEALE, J. F. 1927. Vitamin-like substances in plant nutrition. *Univ. Ariz. College Agric. Exp. Sta. Tech. Bull.* 16: 401-417.
- BRUEHMER, W. G. H. 1927. The origin of the living organism in the light of the new physics. *Med. Times*, 55(11): 247-250, 258. (Not seen.)
- BUCHANAN, A. 1921. Exploration of Air. Out of the World North of Nigeria. London, Murray.
- CLEMENTS, F. E. 1905. Research Methods in Ecology. Lincoln, Univ. Pub. Co.
- . 1920. Plant Indicators. *Carnegie Inst. Wash. Pub.* 290.
- CLEMENTS, F. E., and SHELFORD, V. E. 1927. Concepts and objectives in bio-ecology. *Carnegie*

- Inst. Wash. Year Book* No. 26: 331-332. (Reprint differently pagged.)
- CLEMENTS, F. E., and TAYLOR, W. P. 1923. Principles and methods of bio-ecology. *Carnegie Inst. Wash. Year Book* No. 22: 314-315.
- COOPER, W. S. 1926. The fundamentals of vegetational change. *Ecology*, 7(4): 391-413.
- DARWIN, C. 1889. *Insectivorous Plants*. New York, Appleton.
- . 1898. *The Origin of Species*. Reprint of 6th London Ed. (date?) New York, Eckler.
- FOLSOM, J. W. 1922. Entomology with Special Reference to Its Ecological Aspects. *Philadelphia*, Blakiston's.
- FORBES, S. A. 1887. The lake as a microcosm. *Bull. of the Sci. Ass. of Peoria, Ill.*, pp. 77-87.
- HAECKEL, E. 1904. *The Wonders of Life*. New York, Harper & Brothers.
- HOLMQUIST, A. M. 1928. Notes on the life history and habits of the mound-building ant, *Formica ulkei* Emery. *Ecology*, 9(1): 70-87.
- HUNTINGTON, E. 1931. The Matamek conference on biological cycles, 1931. *Science*, 74(1914): 229-235.
- JEPSON, W. L. 1910. *The Silva of California*. *Mem. Univ. Calif.*, Vol. 2. Berkeley, Univ. Press.
- JONES, G. T. 1926. Pearse's Animal Ecology. *Ecology*, 7(4): 503-504.
- JORDAN, D. S. 1919. *Foot-notes to Evolution*. New York, Appleton.
- LIVINGSTON, B. 1929. Environmental complexes considered as dynamic systems. *Proc. Int. Cong. Plant Sciences, Ithaca*, 1926, 2: 1107-1121.
- LONGSTAFF, T. G. 1932. An ecological reconnaissance in West Greenland. *Jour. Anim. Ecol.*, 1(2): 119-142.
- MCATEE, W. L. 1927a. Notes on insect inhabitants of bird houses. *Proc. Ent. Soc. Wash.*, 29(4): 87-90.
- . 1927b. Bird nests as insect and arachnid hibernacula. *Proc. Ent. Soc. Wash.*, 29(8): 180-184.
- . 1929. Further notes on insect inhabitants of bird houses. *Proc. Ent. Soc. Wash.*, 31(6): 105-111.
- MERRIAM, C. HART. 1890. Results of a Biological Survey of the San Francisco Mountain Region and Desert of the Little Colorado, Arizona. *U. S. Dept. Agric. N. Amer. Fauna* No. 3, pp. vii + 136.
- . 1892. The geographic distribution of life in North America with special reference to the mammalia. *Proc. Biol. Soc. Wash.*, 7: 1-64.
- MÖBIUS, K. 1877. *Die Austern und die Austernwirtschaft*. Berlin. (Not seen.)
- PHILLIPS, J. F. V. 1926. General biology of the flowers, fruits, and young regeneration of the more important species of the Knysna forests. *S. Afr. Jour. Sci.*, 23: 366-417.
- . 1930. Some important vegetation communities in the central province of Tanganyika Territory (formerly German East Africa). A preliminary account. *Jour. Ecol.*, 18(2): 193-234.
- . 1931. The biotic community. *Jour. Ecol.*, 19(1): 1-24.
- PICKENS, A. L. 1929. Bird pollination problems in California. *The Condor*, 31(6): 229-232.
- SEMPER, K. 1881. *Animal Life as Affected by the Natural Conditions of Existence*. New York, Appleton.
- SHELFORD, V. E. 1915. Principles and problems of ecology as illustrated by animals. *Jour. Ecol.*, 3(1): 1-23.
- . 1929. *Laboratory and Field Ecology*. Baltimore, Williams & Wilkins.
- TANLEY, A. G. 1923. *Practical Plant Ecology*. New York, Dodd, Mead.
- . 1929. Succession: The concept and its values. *Proc. Int. Cong. Plant Sciences, Ithaca*, 1926, 1: 677-686.
- TAYLOR, W. P. 1925. Biological stations for the study of plants and animals together. *Scientific Monthly*, 21(4): 390-393.
- . 1927. Ecology or bio-ecology. *Ecology*, 8(2): 280-281.
- THOMAS, B. 1931. A camel journey across the Rub 'al Khali. *The Geog. Jour.*, 78(3): 209-242.
- THORNBUR, J. J. 1909. Vegetation groups of the Desert Laboratory domain. *Carnegie Inst. Wash. Pub.* 113: 103-112.
- TRAGARDH, IVAR. 1924. Problems and methods in forest entomology. *Jour. Forestry*, 22(6): 64-78 October.
- VESTAL, A. G. 1913. An associational study of Illinois sand prairie. *Bull. Ill. State Lab. Nat. Hist.*, 10: 1-96.
- . 1914. Internal relations of terrestrial associations. *Amer. Nat.*, 48(571): 413-445.
- WEBER, A. O. 1925. Animal ecology of an Illinois elm-maple forest. *Ill. Biol. Mon.*, 9(4): 1-93.
- WHEELER, W. M. 1928. *Emergent evolution*. New York, Norton.
- WILLIS, J. C. 1922. *Age and Area*. Cambridge, University Press.
- YAPP, R. H. 1922. The concept of habitat. *Jour. Ecology*, 10(1): 1-17.



DIFFERENTIAL REPRODUCTION IN CHINA

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INTRODUCTION

THE problem of *differential reproduction*, or *differential fertility* as it is termed by some and *differential fecundity* by others, has been studied by eugenics and by sociology for some time as it concerns the different social classes. A considerable body of literature in this field has accumulated, the results of which, for the most part, seem to show that the upper economic classes in Western society are not reproducing themselves as rapidly as are the lower. Since there are many data to show that it is from these upper economic classes that a larger proportion of men of superior ability is produced, the conclusion is reached that this situation is dysgenic. It is not the purpose of the writer to go into this matter for Western countries, but rather to bring forth evidence concerning this problem as it reveals itself in China. While at the outset it must be admitted that statistics for China are few and probably not as reliable as those in the West, yet there is material worth considering and which gives us a picture somewhat different from that found in the West. I shall try to show that in China the upper economic classes have more children per family than the lower economic classes; that modern education tends to *increase* rather than to *decrease* the number of offspring per family.

SIZE OF FAMILIES FROM WHICH STUDENTS COME

There have been a few studies of small groups of families of students in China which give us some idea of the number of children in families of the middle and upper economic classes. These studies have been carried on among Middle School and College students who have to pay a considerable amount in school fees, which fact automatically selects them as being not of the class of coolies, factory operatives, or other very low income groups. The fact that these data were secured through the students themselves means that only families with at least one child could be included. The figures which I shall quote in this section will, therefore, represent only families which have at least one child and which belong to the classes able to send their children to Middle School. It will be observed from a study of Table 1 that in the six studies of families of Middle School and College students the average number of living children falls in general between four and five; the average number of dead children between one and one-half and two; and the total births a little more than, or approximately, six. It is quite likely that in these families a certain number of miscarriages, stillbirths, and abortions have been omitted through failure of the reporting students either to know or to state such facts concerning the puerperal

history of their mothers. Thus it is quite likely that the total number of births reported is smaller than the total number of pregnancies occurring. That differentials prevail even within this fairly homogeneous group of families will be shown later when the education of the parents is analyzed.

SIZE OF FAMILIES AMONG LOWER ECONOMIC GROUPS

For the moment let us leave the educated families and turn to lower economic groups. I have gathered into a table a number of scattered studies made in China

had been married an average of 5.5 years; whereas the 3,042 having children had been married 14.5 years. But even these having children, and having been married nearly fifteen years, had only 1.8 living offspring, and a total of 2.7 births. It is, of course, possible that these fathers omitted some pregnancies which occurred in their families but which did not result satisfactorily.

Dr. Lennox made another study of family size, but this time he investigated the number of children of a highly educated group,—171 modern-trained Chinese physicians whose average age was 36.2 years

TABLE 1
Average Number of Children in Families of Middle School and College Students in China

INVESTIGATOR	NUMBER OF FAMILIES	AVE. NO. LIVING CHILDREN	AVE. NO. DEAD CHILDREN	TOTAL BIRTHS
Griffing (1).....	252	4.32	1.62	5.93*
Griffing (2).....	310	3.98	1.79	5.75*
Lamson (3).....	1778	4.81	#	#
Lamson (4).....	1781	5.03	1.60	6.63
Milam (5).....	800+	4.41	2.10	6.51
Oppenheim (6).....	473	4.22	1.74	5.96

* Griffing's totals do not exactly represent the sum of the two parts within .02, but these are as he gives the total averages.

Data relative to dead children not secured.

aiming to discover the reproduction rate among such families. In Table 2 attention is called to the relatively small number of living children which, even in those families in which the marriage has lasted for eighteen or twenty years, never rises above three, although the cases of Gray, Griffing, and Lamson comprise only families having children and where the information is secured through the mothers chiefly.

In the study of 4,000 married men made by Dr. Lennox he found, as these men came to the out-patient department of the Peiping hospital, that 958 had no children (24 per cent). This group of 958 men

and who had been married an average of 11.1 years. This group of men had 3.46 living children. Thus we note that this selected educated group (probably also from rather well-to-do families) had as the result of 11 years of married life nearly twice as many living children per family as the 3,042 married men of lower economic class who had been married more than three years longer, on the average (11). In this connection Dr. Lennox comments, "Even though educated Chinese are not married until age 25 (Chinese count) they have children at a rate which will give seven children to the family, if

marriage lasts through 21 years of the wife's child-bearing period."

Returning to the study of 4,000 lower class fathers by Dr. Lennox we find that, taking the 1,148 fathers who were married before they were 26 years old and married more than 15 years, there were 3.4 children on the average per father. Of these 1.1 had died leaving 2.3 living per family. The author concludes, "On the whole,

Seven are married but have no children; two are unmarried; and two are in their first pregnancy. We have included only the 63 in the last line of the table. The 72 amahs were asked whether or not they desired any more children, to which 39 replied negatively, and 33 affirmatively. The data for those *not* desiring further offspring are as follows: average age, 42.5 years; average pregnancies, 3.89; average

TABLE 2
Number of Children of Middle and Lower Economic Groups and Those with Little Education in China

INVESTIGATOR	TYPE OF FAMILIES	NO. OF FAMILIES	AVE. LIVING CHILDREN	AVE. DEAD CHILDREN	AVE. TOTAL CHILDREN	AGE OF SPECIFIED PARENT	DURATION OF MARRIAGE
Lennox (7)	Peiping lower & middle	4,000	1.4	0.7	2.1	30 yrs 32.8 Father	30 yrs 12.3 (A)
		3,042	1.8	0.9	2.7	?	14.5 (B)
Gray (8)	Charity hospital mothers	1,000	2.3	2.4	4.7	Mother about 40	20.0
Hammond & Hsu (9)	Peiping largely middle	903	2.6	1.1	3.7	?	?
Griffing (2)	Rural uneducated	220	2.99	2.33	5.32	Mother 39 or over	At least 20 years
Lamson (10)	Amahs' mothers' children	74	2.77	2.42	5.19	?	Families probably complete
Lamson (10)	Amahs' own children	63	2.06	1.62	3.68	Mother 37.7	About 18 years

A—Total married men. B—Those with children.

these figures show that the Chinese lower classes have much smaller families than is generally supposed."

I made a small study in Shanghai in 1933 of a group of amahs (women servants) aiming to discover facts relative to family size both of the amahs themselves and of their mothers. Some of the results are shown in the last two lines in Table 2. In the case of the amahs themselves we find 63 who are married and have children.

living children per woman, 2.17. The figures for those women who desire more children are: average age, 32.1 years; average pregnancies, 2.51; average living children, 1.36. If we count the number of children this last class of women have *living* and add the number they *desire* in addition we find that the *total wanted* averages 3.7 children, slightly less than the total average pregnancies of those who do *not* want any more, 3.89.

There have been made in China several small studies of families of lower economic groups such as coolies, factory hands, common peasants, from the point of view of the standard of living. Most of such studies, which we have not space here to quote in detail, give the total number of persons in the families, or averages which show us the total number of *persons* living together in a family unit. The figure runs from about 3.5 to 6.00 persons, with four and five the more common number. *If* these families consisted only of two parents and offspring the average number of children would then be between 1.5 and 4.00, with two and three the more common number, *but* we cannot make this assumption since in some families one parent is dead, and uncles, cousins, or grandparents may be present. This being so, the number suggested for offspring would have to be still further reduced.

DIFFERENTIAL REPRODUCTION BETWEEN UPPER AND LOWER GROUPS

We have discussed the size of family of certain upper economic class groups and also of certain lower groups. It now remains to put together from these studies certain comparative material by age groups in order that the contrasts in reproductive rates can be more clearly observed. Unfortunately we have to deal with studies which are not standardized in all respects. The samples are from different places, by different investigators, of different sizes, and of age-groups which do not precisely correspond, but even so this seems to represent a worthwhile preliminary attempt at analyzing what material we have. Table 3 gives the details from which Chart 1 is drawn.

It will be noted in Chart 1 that for each of the four age groups both the average number of surviving offspring and the total

births per family for the upper economic groups are considerably in the lead over the lower economic groups. This chart seems to reveal dramatically the reverse of the differential reproduction situation in the United States.

NUMBER OF OFFSPRING AND EDUCATION OF PARENTS

In Table 1 data were presented showing the number of children in families of Middle School and College students in

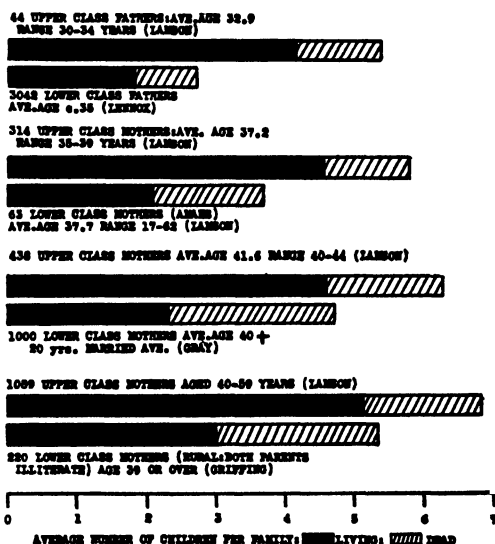


CHART 1. DIFFERENTIAL REPRODUCTION BETWEEN
UPPER AND LOWER ECONOMIC GROUPS IN CHINA,
ARRANGED BY CORRESPONDING AGE GROUPS, IN-
CLUDING MARRIED PERSONS WITH CHILDREN ONLY

China. I now propose to give further details to show that even in this group which has been designated roughly as "upper economic group" there are differentials which further substantiate the main thesis of this paper.

In Chart 2 I have presented in a graphic form data concerning education of the mother and of the father in relation to number of living and dead offspring as found by Griffing in his studies of families of mothers of students in East China. It

will be noted that where both parents are literate both the average number of surviving children and total births are higher than in the case of families in which one or both parents are illiterate.

In Chart 3 there is given material from other studies by Griffing, these having been made by direct survey in rural districts in East China. In this case nearly all mothers are illiterate. There is a regular rise in the number of surviving children as we proceed from the 220 families in which the husband has no education up through the 61 families in

children, number of dead offspring, and total births per family in the groups as stated. It will be observed that the group having the highest number of living children and total births is that in which both parents are Christian and educated. Without regard to education, families in which the parents are Christian are larger than those which are non-Christian. These contrasts are shown in the upper three bars. When the families are arranged according to literacy of parents without regard to religious affiliation we again note the regular rise both in living children

TABLE 3

Differential Reproduction between Upper and Lower Economic Groups in China Arranged by Corresponding Age Groups, Including Married Persons with Children Only

ECONOMIC CLASS	INVESTIGATOR	NUMBER OF FAMILIES	BY AGE OF WHICH PARENT	AGE OF SPECIFIED PARENT (years)		AVERAGE NUMBER CHILDREN PER FAMILY		
				Average	Range	Living	Dead	Total
1. Upper.....	Lamson (4)	44	Father	32.9	30-34	4.11	1.25	5.36
2. Lower.....	Lennox (7)	3,042	Father	35.0	?	1.80	0.90	2.70
3. Upper.....	Lamson (4)	314	Mother	37.2	35-39	4.51	1.26	5.77
4. Lower.....	Lamson (10)	63	Mother	37.7	17-62	2.06	1.62	3.68
5. Upper.....	Lamson (4)	438	Mother	41.6	40-44	4.57	1.68	6.25
6. Lower.....	Gray (7)	1,000	Mother	40+	?	2.30	2.40	4.70
7. Upper.....	Lamson (4)	1,089	Mother	?	40-59	5.10	1.74	6.84
8. Lower.....	Griffing (2)	220	Mother	?	39 up	2.99	2.33	5.32

which he has from one to four years schooling, to the 164 families in which the husband has five or more years of education. In the case of the total births the rise is irregular. However, both groups in which the husband has some education show a higher average of births per family than the group in which the husband is without education.

In Chart 4 I have graphically presented Griffing's findings from the students in two colleges and one middle school in Nanking (1). The figures to the left of the bars show the average number of living

and total births as we go from the 15 families in which both parents are illiterate to the 116 in which only the mother is illiterate, and to the 112 families in which both parents are literate. This study seems to show that families with most education and most Western influence in their lives (as shown by taking on a new religion) have the largest number of offspring born and surviving.

Having quoted the results of studies by J. B. Griffing I shall now give material from my own studies which confirm his general results. Table 4 presents figures

showing the rise in average number of living children (living at the time the study was made) for a group of 307 mothers of eight Shanghai Middle Schools, and for 545 fathers; the increase being from the less educated to the more educated. This group of families averages 5.06 or 5.15 living children and represents those in which the parents have some degree of modern-type education. Since

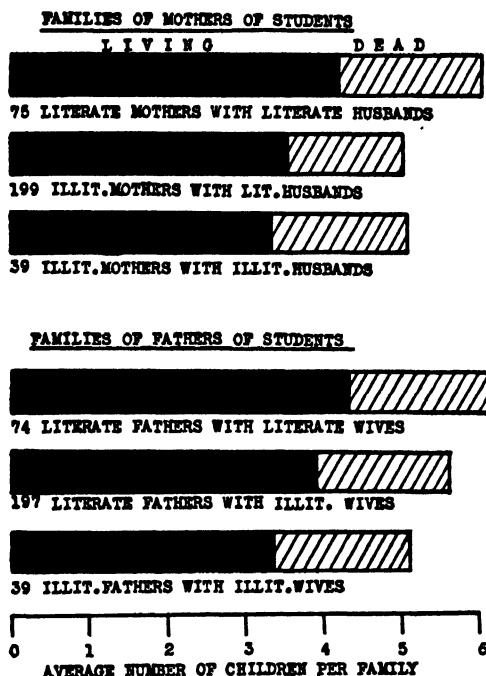


CHART 2. EDUCATION OF PARENTS AND NUMBER OF OFFSPRING, EAST CHINA
(Studies by J. B. Griffing)

the average living children for the whole series of 1778 families comes to 4.81 we can see that this small group, in which the parents do have this modern training, contains larger families than the remainder in the study. In this particular study data relative to dead children were not secured.

In Table 1 at the beginning of this paper a second study by the present writer was

mentioned. I now desire to analyze this in a similar manner, as it seems to show that education does not cut down, but rather seems to increase, fertility. This

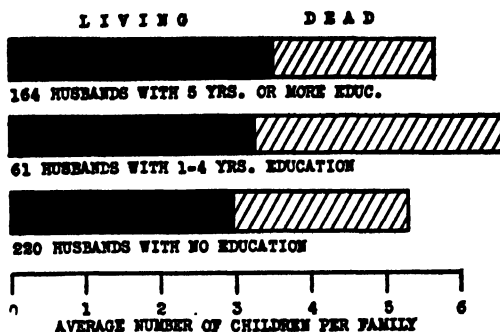


CHART 3. FAMILIES OF MATURE MOTHERS IN RURAL AREAS; MOTHERS NEARLY ALL ILLITERATE (EAST CHINA)
(Studies by J. B. Griffing)

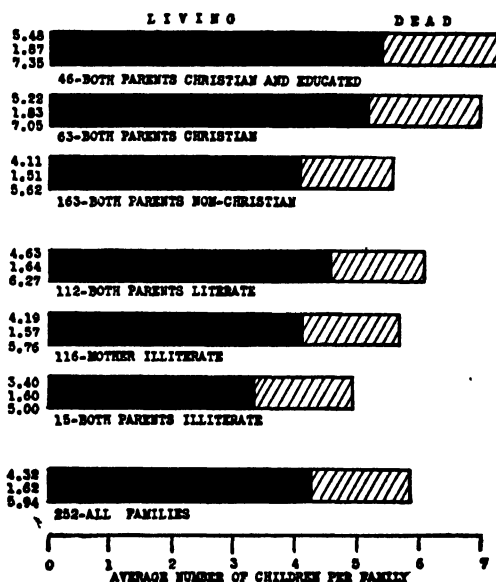


CHART 4. COMPARISON OF FAMILIES OF MOTHERS OF STUDENTS IN NANKING; AVERAGE NUMBER OF CHILDREN BY EDUCATION OF PARENTS
(Studies by J. B. Griffing)

is not to be taken as meaning that more education "causes" increased fertility, but that it certainly is associated with it. The study was made in East China in fifteen Middle Schools; one in Kinkwa,

three in Soochow, and the remainder in Shanghai. Table 5 gives the distribution according to size.

In this study the average age of the reporting students is for males 16.91 years, and for females 16.69, both sexes considered as a unit 16.82 years. The average

age of parents is 44.43 years for mothers and 47.31 years for fathers. The average number of living children per family is 5.03; children who had died 1.6; and total births 6.63 per family. As will be noted from Table 5 the modal size for total births is the six-child family, with the

TABLE 4

Living Offspring of Families of Students of Eight Middle Schools in Shanghai According to Education of Parents (3)

EDUCATION OF STATED PARENT	MOTHERS		FATHERS	
	Number of families	Average living children	Number of families	Average living children
Studied in or graduated from Primary School	165	4 88	97	4 65
Studied in or graduated from Middle School	119	5 14	192	4 98
Studied in or graduated from College	23	5 91	131	5 29
Studied abroad . . .	—	—	125	5 44
Total and Weighted Average	307	5 06	545	5 15

TABLE 5

Total Births per Family in 1781 Families of Middle School Students in East China

TOTAL BIRTHS PER FAMILY	NUMBER OF FAMILIES	PER CENT OF TOTAL FAMILIES	TOTAL NUMBER OF CHILDREN	PER CENT OF TOTAL CHILDREN
1	65	3 65	65	55
2	88	4 94	176	1 49
3	128	7 19	384	3 25
4	180	10 11	720	6 09
5	218	12 24	1,090	9 23
6	244	13 70	1,464	12 39
7	237	13 31	1,659	14 05
8	189	10 62	1,512	12 80
9	130	7 29	1,170	9 91
10	94	5 28	940	7 96
11	82	4 60	902	7 64
12	48	2 69	576	4 88
13	33	1 85	429	3 63
14	15	.84	210	1 79
15	9	.51	135	1 14
16	6	.34	96	.81
17	5	.28	85	.72
18	3	.17	54	.46
19	2	.11	38	.32
20	2	.11	40	.34
21	2	.11	42	.36
22	1	.06	22	.19
Total..	1,781	100	11,809	100

seven-child family a close second. Attention is called to the relation between the two percentage columns in this table. Up to and including the six-child family the percentage of families to total families exceeds the percentage of children to total offspring, but from the seven-child family upwards the reverse is the case. For example, although the seven-child families constitute 13.31 per cent of the total number of families in the series, this set of 237 families contributes 14.05 per cent of all the children. And although the 218 five-child families constitute 12.24 per cent of all families they contribute but 9.23 per cent of the total children. The table contains no childless families since information was secured through Middle School students concerning their own brothers and sisters.

Table 6 presents an analysis of these 1781 families according to education, as far as that information was given. The average number of children is arranged according to (1) the education of the mothers, and (2) the education of fathers.

An added column is to be noted which shows the percentage of children that have died in the families. Both in the groups arranged by mothers' education and in those arranged by that of the fathers we note that those parents recorded as having had no education have a higher proportion of dead children than the others. In the case of families arranged by mothers this runs from 26.92 per cent

However, it may be pointed out that the difference is not great, the total average number of children being above six. In this connection it should be mentioned that in this group of families of Middle School students the term "No Education" is not to be interpreted as meaning illiterate coolies or factory hands. There is a considerable number of families in China which are financially able to send one or

TABLE 6

Education of Parents and Number of Children, Families of Middle School Students (4)

	TYPE OF EDUCATION	AVERAGE CHILDREN PER FAMILY			PER CENT DEAD CHILDREN
		Living	Dead	Total	
NUMBER OF MOTHERS	FAMILIES ARRANGED BY EDUCATION OF MOTHER				
503	No Education	4 61	1 70	6 31	26 92
418	Some Private Education	5 17	1 64	6 82	24 16
485	Some Modern Education	5 10	1 48	6 58	22 44
159	Primary School	4 52	1 47	5 99	24 54
260	Middle School	5 11	1 36	6 47	20 97
34	College	5 44	1 50	6 94	21 61
32	Study Abroad	7 62	2 47	10 09	24 45
NUMBER OF FATHERS	FAMILIES ARRANGED BY EDUCATION OF FATHER				
69	No Education	4 65	1 82	6 47	28 18
535	Some Private Education	4 98	1 74	6 73	25 91
858	Some Modern Education	5 13	1 59	6 72	23 65
83	Primary School	4 95	2 35	7 30	32 16
279	Middle School	5 20	1 76	6 96	25 33
232	College	4 74	1 31	6 05	21 58
264	Study Abroad	5 47	1 42	6 89	20 62

for mothers with no education to 24.16 for mothers with some private (presumably old style) education, and to 22.44 for those with some modern schooling. Corresponding figures for fathers are: 28.18 to 25.91 to 23.65 per cent.

Both in the case of the families arranged by fathers and by mothers we find that parents with *some* education have a larger average number of living and of total children than those with none.

more children to Middle School and who at the same time have mothers or fathers without education. As Table 6 shows, this class is much larger among mothers than among fathers, the figures being 503 to 69. This is not surprising when we call to mind the fact that education for women in China, traditionally, has not been given the emphasis that education for men has received.

In the case of the families arranged by

education of mothers in Table 6 we find, when we break up the 485 in which the mother has had some modern education, that there is an increase both in living and in total average children as education increases. This tendency is not as apparent in the corresponding figures for fathers. It may be suggested by way of explanation that in the case of educated mothers there is much more likely to be an educated father (that is, husband) than that all educated fathers will have educated wives. In other words, in those families in which the mother has some modern education the chances are greater that both parents will be educated than in those families in which the father is educated. The reason for this is that educated women do not want, and may even refuse to accept, husbands with education inferior to their own; whereas educated husbands may, owing to the greater relative scarcity of educated women, be forced to marry a woman without education, or at least with education considerably inferior to his own. In fact, a highly educated man may prefer to have a wife whose education is inferior to his for various subtle reasons. This is offered as a possible reason for the greater regularity in the rise of the number of children (as education increases) in the mothers' column than in the fathers'.

In the study of student homes in China by Milam (5), mentioned in Table 1, it was found that for the 259 families whose annual incomes averaged \$1000 (Chinese currency) or above, the average number of living children was 5.5; dead children, 2.1; and total births, 7.6. Corresponding figures for 292 families whose annual incomes averaged less than \$1000 came to 4.3 living; 2.1 dead; and 6.4 total births.

In the other studies of students' families income was not ascertained. Students do not seem, in general, to give very reliable data in regard to the income of their par-

ents; for this reason the present writer has not included such data in his studies. We can infer in a rough manner that families which send their children to middle school and college are in a better economic situation than domestic servants and factory operatives. The facilities for "working your way through" school are not as numerous in China as in the United States. It is impossible at present to ascertain with exactness which of several variables is responsible for the differential rate of reproduction which seems to exist in China. It is quite likely that several variables are functionally related: income, degree of education, environmental conditions, inherent ability, and fertility.

It is of further interest to note that, in both of the studies which I made in East China, of all occupations of fathers of Middle School students physicians show the highest average number of children. In the 1781-family study the 61 physicians, although averaging only 46.47 years, have 6.13 living children, 1.51 dead, and 7.64 total births per family. In the same study 121 fathers listed as "agriculturalists" (rural dwellers, landlords, farmers) average 50.86 years and have 4.95 living, 1.67 dead, and 6.62 total children.

AGE OF PARENTS AND NUMBER OF OFFSPRING

In this study of 1781 families we may briefly summarize the findings in regard to age classification. Since the material was secured through students in Middle School whose minimum age was 10 we may say that our families have been married at least 11 years. This gives us relatively few parents under thirty years of age. Fathers in their thirties have an average of 5.89 births in their families; those in their forties, 6.54; in their fifties, 7.4; in their sixties, 7.88. The six fathers in their seventies average each eight children.

The average number of both living and dead children increases with the age of the father. The same general phenomenon appears in the case of the families arranged by age of mothers. Mothers in their thirties have in all 5.97 births; those in their forties, 6.68; in their fifties, 7.20; and in their sixties, 7.53. The 56 families in which the mother is reported as dead have a still higher number of births, averaging 8.8. If we consider the families of mothers in their fifties or above we find that the average total births is well above seven, and in the case of the dead mothers nearly nine.

Comparing the total number of children, living and dead, for each of the four significant age groups according to fathers and mothers respectively, we see that the fathers have a smaller average number of children than the mothers in the thirties and forties, but that the fathers are ahead in the fifties and sixties.

I wish to report briefly upon another study (12), dealing with age and number of offspring, made in Shanghai through a class of women college students who collected information from their relatives and friends (women) who were married and for the most part women of some education. Information was secured for 120 such women. For these we find the average number of pregnancies rising from 1.89 to 3.44 to 6.33 as the average length of marriage increases from 3.07 years to 7.62 to 13.33 years. Since these women were on the whole relatively young we do not have many cases of those married more than fifteen years. There are seven women married over 25 years and these have an average of over seven pregnancies. For the first three age groups the average number of living offspring (at the time of the study) rises from 1.48 to 2.59 to 4.28 as the average age of the mothers increases from 24.93 to 30.15 to 34.44 years.

The number of married years *per pregnancy* for those 54 women married 1-5 years comes to 1.63 years; for the 27 women married 6-10 years the corresponding figure is 2.22; for the 18 women married 11-15 years 2.11; for the 8 women married 16-20 years 3.6; and for the 6 women married 21-25 years there is one pregnancy on the average for every 3.5 years married. In this series of 120 married women whose average age was 30.73 we discovered out of 447 pregnancies four admitted abortions and 32 miscarriages. This gives us a hint that in our other studies of over 1700 families there must have been a considerably larger number of pregnancies than of total births.

AGE AT MARRIAGE

Information regarding age at marriage is rather fragmentary. We do not have space here to include a few tables available from small studies. In general we may say that among those groups in contact with modern ideas the age at marriage is gradually rising, both for female factory operatives (13) and of course for those educated classes with whom attendance at college and graduate schools is becoming more common. In the study made by Dr. Lennox of 4,000 married men of middle and lower classes, the largest number of men married at age 19 (Western reckoning), with 18, 17, 16, and 20 following in that order. This same investigator found among modern Chinese physicians a range of age at marriage from 14 to 46 averaging 24.7 years, with the mode at 26 years. Dr. Lennox stated that of his 4,000 men of middle and lower classes 54 per cent married before age of 20 but that these had no more children than those marrying after age 20.

In my study of 72 amahs (lower economic class) age at marriage ranged from 14 to 25 (Western reckoning); the largest

number occurred at 18, age 17 and 16 nearly tying for second place. The 17 amahs marrying in the decade 1924-1933 averaged 18.8 years at marriage; the 11 marrying in the decade 1894-1903 averaged 17.9; and the six women married between 1884 and 1893 averaged 17.5 years at marriage.

In my study of the 120 educated married women there is noted a rising age at marriage. The general average is at 21.44 years. For the 81 women married ten years or less, wedded in the decade 1921-1931, the average age at marriage is 22.07. For the 26 cases marrying in the period 1911-1921 the figure is 20.76; and for the ten women married in the decade 1901-1911 the mean age at marriage is 18.9 years.

The rather rapidly expanding opportunities for careers for women in China, whether in factories or in the professions, means postponement of marriage, and for some it means that they will never marry. Under the traditional system everyone in the community was expected to marry and parents made the arrangements; now with a rapid increase of Western influence young persons, especially in towns and cities, seek to choose their own mates, or may even choose not to marry. However, strong traditions of family life still prevail even among the educated. We do not know what proportion of the people do not marry, nor do we know what proportion of college girls remain single. Coeducation and special institutions of higher learning for women are of such recent development that the time is not yet ripe for comparative studies with those in the West.

FAMILY LIMITATION AMONG EDUCATED CLASSES

Elsewhere (12) I have attempted to secure information relative to family

limitation for two groups of educated Chinese women. In one of these (the Shanghai study of 120 married women) it was found that nearly all of the women stated that they had known women whose too-frequent childbearing had resulted in deterioration of health of the mother. About nine-tenths of these women believed that women in general should be able to regulate the coming of their children and expressed themselves as being willing to receive contraceptive information. As nearly as could be determined, not more than about 17 per cent of the women had knowledge of modern contraceptive methods.

While our figures tend to show that education does not cut down fertility among those families with at least one child, but rather seems to be associated with increased rate of reproduction, yet we have to admit that gradually this knowledge of birth control is spreading and the idea of smaller families is penetrating. Books on birth control have been translated into Chinese; an experimental clinic has started in Peiping; educated Chinese appreciate the dangers of an overcrowded population; some drug stores sell contraceptives; those of the student class about to be married are asking to be directed to contraceptive information. These are straws in the wind and it is quite possible that the conditions described in this paper may be reversed after a period of years has elapsed. One thing seems fairly certain, namely, that knowledge of methods of contraception will penetrate, are penetrating, among upper economic classes before they reach the lower classes. Abortion, infanticide, neglect, and sale of children still remain, of course, as means by which the lower class families may rid themselves of surplus mouths.

THE SECONDARY MOTHER

The question may have occurred to someone, "Since the more highly educated classes are the ones which have the most money, may it not be possible that the birth differential is due to plural wives in the same family?" From the data secured in my study of 1781 families of Middle School students the answer is in the negative. Here I can consider this question only very briefly, although I hope to present more details in a later article. Out of 1781 families 202, or 11.34 per cent contained one concubine or more. The total number of concubines came to 256, making an average of 1.26 per family having these secondary mothers. Although families with a concubine constitute 11.34 per cent of all families, they produce only 9.21 per cent of all children. (This means that this amount is produced by the family in which the concubine is found, not the production of the concubines alone.) Of all the births in the 1781 families the "big wife," or the first wife, produces 92.53 per cent, more than nine-tenths. Stepmothers produce 3.27 and concubines 4.2 per cent of all births.

In our 1781 families there are 1579 with no concubine, 166 families with one; 26 families with 2 each; six families with 3 each; one family with 4; two with 5, and one with 6 concubines. The average number of births in families with no concubines is larger (6.79) than for any of the groups having one or more concubines, except the one family with five concubines. The 166 families in which there is one concubine each, average 5.2 total births per family. The 26 families in which there are two concubines each, average 5.92 children (living and dead) per family. And the six families in which there are three concubines each, average 6.5 children. These are rather unexpected find-

ings which we do not have space here to discuss in detail. We may conclude that, as far as our series is concerned, differential reproduction is not to be explained by the secondary mother.

FINAL CONSIDERATIONS

If we grant that there are different reproductive rates apparent between the upper and lower economic classes in favor of the upper, what are the possible explanations?

- (I) That there is a difference in *conception* rates.
 - (A) Extrinsic factors. (1) Greater incidence of disease among lower classes, (2) Possibly greater proportion of unmarried among the poor, (3) Nutritional defects greater, (4) Psychological effects of poor environment, (5) Greater density of population per room among the poor (Cf R. Pearl's theories).
 - (B) Intrinsic factors. (1) Greater proportion of childless among poor, (2) Prolongation of nursing period among lower class mothers, (3) Lower physical vitality, (4) An established evolutionary biological difference in innate ability, including fertility, among the classes.
- (II) That there is no difference in the rate of *conception*, but that the difference begins to be noticed in the *birth* rates.
 - (A) Economic pressure impinges more heavily upon the lower economic classes and leads to a larger proportion of unsuccessful pregnancies. (1) Through artificially induced miscarriage (abortion) wilfully undertaken by the mother or midwife, (2) Through accidental miscarriage brought on by hard work, accidental injury, or some vital deficiency, (3) Through a larger proportion of stillbirths and birth trauma cases, due to unskilful assistance or lack of aid at birth.
 - (B) That the traditional belief in the importance of a large number of offspring (especially sons), plus financial ability to carry this into effect, is stronger among upper economic groups, leading to relatively less wilful interference with pregnancy.
 - (C) Or that these traditional beliefs are equally strong in all classes, but that economic pressure forces the lower classes to limit the number of births through abortion.
- (III) That there is no difference in *conception* rates or

in birth rates, but that there is a difference in survival rates.

- (A) Greater amount of infanticide among lower classes: (1) Through outright destruction of life; (2) Through gradual neglect due to lack of interest in having that child survive.
- (B) Greater amount of deaths soon after birth from: (1) Ignorance of proper child care; (2) Inability to furnish the child with what it needs, among the lower economic groups.
- (C) Greater proportion of child deaths at varying ages among the poor due to: (1) Accidents through lack of care by mothers working away from home; (2) Sickness due to unhealthful surroundings; (3) Death from ignorance or inability to secure medical attention; (4) Superstitious practices ending in death.
- (D) Greater failure among poor to report pregnancies or births which miscarry, are still-born, or which die soon after birth, such happenings not being regarded as "children."

Considerable further research is needed to prove or disprove some of the above points. I am inclined to believe that all three of these major factors enter into the picture (conception rates, birth rates, and survival rates). There would seem to be no question (1) that the upper economic classes have greater survival rates. It is fairly certain (2) that the upper economic classes who are married have a higher birth rate than the lower who are married. We do not know the relative proportion of unmarried in the classes, nor do we know the differential in the number of childless marriages. (3) There are still less certain data as to whether the lower economic classes actually have a lower conception rate or not. However, I hazard the inference from this paper that there is a strong probability that even in conception rates a differential favoring the upper classes is present.

Turning now from the particular considerations to more general theoretical

subjects concerning upper and lower economic classes in China, the following observations are made as having a bearing.

(1) Assortive mating has been and seems to be going on; since marriages under the old system were made by the parents through a middleman it is probable that there has been more intra-class than inter-class mating. (2) This would tend in time to bring about a real biological cleavage between the social classes (14). (3) Even among modern educated groups in China among whom parental arrangement for marriage is becoming less common, there is still a tendency for marriage to keep within certain class lines. (4) Calamities such as civil war, famines, floods, plagues (while they may kill off the weaker, yet upon those who do survive) may have a weakening effect which is more noticeable among the poor, who are less able to get away from the scene of the trouble, or to rehabilitate themselves afterwards. (5) There is some vertical mobility continually taking place between the classes. Bright boys from among the peasant class, for example, have been selected and given an education with the definite idea that they will rise above their relatives and perhaps become scholars or officials. This has brought capacity and ability from lower to upper classes. On the other hand, the rich opium addict may gradually smoke away all his possessions and be reduced to beggary.

These general remarks are intended to propose the thesis that *one* of the reasons for the favorable and eugenic differential reproduction rates among the upper, educated, classes in China is to be found in an innate biological superiority, including greater reproductive power, of the upper economic classes over the lower. Differential reproduction at present seems to be eugenic in China.

LIST OF LITERATURE

1. J. B. GRIFFING, Size of family and education in China, *Sociology and Social Research*, Sept.-Oct. 1928, pp. 63-72.
2. J. B. GRIFFING, Education and size of family in China, *Journal of Heredity*, Sept. 1926, pp. 331-337.
3. H. D. LAMBON, A study of the relation of education to family size, *China Critic* (Shanghai), Aug. 21, 1930, pp. 799-802.
4. H. D. LAMBON, Population studies: Size of the Chinese family in relation to occupation, age, and education, *Chinese Economic Journal* (Shanghai), Dec. 1932, pp. 478-496.
5. A. B. MILAM, A Study of the Student Homes of China, New York, Columbia University, 1930, Ch. 5.
6. F. OPPENHEIM, Birth and death ratios of the Chinese, *China Journal of Science and Arts* (Shanghai), 1924, pp. 466-477.
7. W. G. LENNOX, Some vital statistics based on the histories of 4,000 Chinese families, *China Medical Journal* (Shanghai), 1919, p. 325.
8. DR. GRAY's study quoted in 7.
9. J. HAMMOND and K. L. HSU, A note on infant and child mortality in North China, *China Medical Journal* (Shanghai), 1927, p. 1006.
10. H. D. LAMBON, unpublished material gathered 1933.
11. W. G. LENNOX, Vital statistics of families of Chinese physicians, *China Medical Journal* (Shanghai), 1932, pp. 277-283.
12. H. D. LAMBON, Family limitation among educated Chinese married women, *Chinese Medical Journal* (Peiping), 1933, pp. 493-503.
13. H. D. LAMBON, The effect of industrialization upon village livelihood, *Chinese Economic Journal* (Shanghai), Oct. 1931, pp. 1025-1082.
14. SERIES of articles in *Social Forces*, Oct. 1933, pp. 1-47.





THE ELECTRO-DYNAMIC THEORY OF LIFE

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THERE are several factors which suggest that living things must be viewed from the electro-dynamic point of view. Certain of these factors appear in the non-biological sciences and in general philosophical considerations; others arise in biology itself, and particularly in connection with recent evidence concerning the factors controlling the development of the nervous system.

I. GENERAL SCIENTIFIC AND PHILOSOPHICAL CONSIDERATIONS

If one views the history of science as a whole, including its Greek as well as its modern manifestations, a certain contrast appears. Greek science was dominated largely by mathematics and astronomy, whereas since the seventeenth century physics and chemistry have been the leading disciplines. This difference in emphasis among the special sciences bespeaks a more fundamental difference in scientific outlook. Mathematics and astronomy as they appeared in Greek times in the geometry of Euclid and in the mathematical astronomy of Eudoxus, were systematic deductive sciences dealing with the entire spatial and astronomical universe as a whole. It is an obvious peculiarity of geometry as a pure science that it is concerned wholly with structure and not at all with matter. It is a more unexpected peculiarity of astronomy that it, more than any other of the natural sciences, tends to conceive of nature as a purely formal system. This was the case in Greek times and with Kepler, and is, or was, the case in our own time with Eddington and Jeans. It was not the case,

however, with Galilei and Newton. They conceived of the astronomical universe as a physical system analogous to the system of earth and ball and inclined plane with which Galilei verified his profound and revolutionary reflections.

This brings us to the sharp contrast between traditional modern science and Greek science. The latter, dominated as it was by such scientists as Eudoxus, Euclid, Apollonius and Archimedes, tended to regard mathematics as more fundamental than physics and to think of nature as a purely formal structure; the former, following Galilei and Newton, made physics primary, and hence regarded nature as an aggregate of many physical objects in motion, mathematics becoming a very necessary means, but nevertheless merely a means, of precisely formulating this physical conception. Stated in more general philosophical terms, Greek science, including biology with Aristotle, tended to conceive of nature in terms of formal causes; modern science, in terms of material causes. The two views have not been compatible in traditional scientific or philosophical theory. To maintain that nature is a system of forms, unconditioned by matter, is to maintain that nature and its systems possess a changeless structure; hence, the doctrine of the fixity of biological types in Greek biology. To maintain that nature is a collection of physical objects in motion is to regard structure as a relation between these objects, and subject to change with their motion; hence, the essentially modern character of Darwin's doctrine of the modification of biological types. In

short, Greek inorganic and organic science put the emphasis on structure and the eternal constancy of forms whereas modern science has placed the emphasis on physical and chemical and biological entities and the variability and evolution of forms.

This difference between Greek and modern science exhibits itself in one contrast which is implicit in what we have already indicated. The ancient emphasis on structure and on systematic science, such as appeared in the geometry of Euclid and the astronomy of Eudoxus, led to the conception of nature as a single system. This means that no local system can be completely understood by itself and that thoroughgoing specialization is not sound science; nothing is truly understood until nature as a whole is understood and the local part is perceived in its exact status in and connection with that whole. This was one of the major reasons why Greek science was so inherently and inescapably philosophical. The modern conception, arising with Galilei's founding of "the science of local motion," and with Newton's principle of isolation and the attendant emphasis on masses rather than structure, led naturally to the conception of nature as an aggregate of many physical objects; hence, the current notion that scientific knowledge is possible for a person only in a very narrow field, and the attendant corollary that any attempt, such as the philosopher sometimes proposes, to talk about the whole, is idle footless speculation.

This opposition expresses itself in one other distinction: Greek science, except for the atomists, who were repudiated in mathematics, for reasons which we shall show immediately, placed the emphasis on continuity; modern science, on discontinuity. The reason for the Greek point of view is to be found in the discovery of the incommensurable by the Pythagore-

ans. They and the atomists, like the moderns, began with a discontinuous theory. The attempt was made to build up lines and surfaces and solids out of discontinuous elements or "pebbles." In short, they tried to define the continuous in terms of the discontinuous, and to reduce geometry to arithmetic. This worked beautifully until they came upon the length of the hypotenuse of a right-angled triangle, the other two sides of which are equal. Setting the sides equal to unity the length of the hypotenuse is $\sqrt{2}$. Stated in more concrete terms, this means that any "pebble" or unit of length which goes into the length of either side a definite number of times leaving nothing over, will always leave something over when the hypotenuse is measured. This convinced the Greeks that the continuous will not reduce to the discontinuous and that geometry is more fundamental than arithmetic (Euclid, V). Bk. Modern science, on the other hand, discovered nature to be atomic, reduced geometry to arithmetic by generalizing its theory of number (Dedekind, Cantor), and regarded discontinuity, and the many, as more fundamental than continuity, and the one.

This modern emphasis on entities, fluid forms, atomicity and discontinuity has dominated biological thought. Galilei had no more than developed his physical and mechanical theory of the inorganic universe before Harvey proceeded to apply physical and mechanical conceptions to living creatures in the discovery of the circulation of the blood. Lavoisier revealed the chemical character of respiration and metabolism in living things at the same time that he placed chemistry upon secure foundations with the discovery of the principle of the conservation of mass. Gradually with Liebig and Wöhler, and the vast army of physiologi-

cal chemists, the chemical nature of living creatures has become more and more evident. It is to be noted that this is a distinctly modern emphasis. Chemistry rests upon a discontinuous atomic conception of nature, and atomism in its traditional interpretation involves an emphasis upon entities rather than upon structure and on the constituent elements rather than upon the whole. This attitude of mind has gone all through biology even where no appeal has been made to the chemical nature of the processes or factors considered. Practically a century ago Schleiden and Schwann discovered the cellular nature of plants and animals. Here was the supposedly ultimate biological atom. More recently the emphasis has shifted from the cell to the gene, but even so the emphasis is still on entities.

It is to be noted that this entire development involves the carrying over into biology of a philosophical standpoint which was discovered and clearly formulated first in physics and chemistry. There can be no doubt of its success or validity. There is nothing to date to indicate that the biologist should hesitate to follow the lead which the more mature and exact science of physics gives him.

If this be granted then it is clear that a slight change of emphasis must come into biological theory. For the entire modern standpoint with its emphasis on entities rather than organization, upon discontinuity rather than continuity, upon local systems rather than upon their status in the total field of nature as a whole, has been found in physics to need rather radical and thoroughgoing supplementation. The word supplementation is to be emphasized, for the modern standpoint has not been rejected; it is being merely amended. The amendment is so thoroughgoing, however, as to amount to the placing of the Greek upon an equal footing

with the modern standpoint. Moreover, the concepts modified are so primary in the levels of importance and so general and universal in their application that every branch of human activity, and even the very meaning and significance of any fact we observe or experiment we perform are affected.

The elemental and essential fact as it appears in physics can be stated very briefly; atomic physics has had to be supplemented with field physics. The point to be noted is that the particle both conditions and is conditioned by its field. Stated in more general terms this means that continuity as well as discontinuity is ultimate, that nature is both one and many. In short, any local system in part constitutes and is in part constituted in its behavior by nature as a whole (Freundlich, 1933) and the physical field in which it is embedded. This rediscovery of the continuous field, or the one, as a causal factor conditioning the behavior of the constituent particles, or the many, is a return to the Greek standpoint. But the particles also determine the character of the field. This is the modern viewpoint. The reciprocal causal relation between field and particle amounts to a union of both viewpoints. This is the fact which anyone with an eye to first principles can see standing out amid all the complexities and confusions of current discoveries in physics.

But this mere designation of the fact is not enough. We do not possess science until our findings are formulated in terms of clear consistent principles. At this point current scientific and philosophical thought is confronted with a serious difficulty. According to all traditional scientific and philosophical conceptions the Greek and Modern views of science contradict each other. It was precisely because of this contradiction that we had to

reject Plato's and Aristotle's physics, biology, and philosophy in order to accept Galilei's, Newton's, and Darwin's. The difficulty can be put very simply. The modern conception of nature as a discontinuous collection of moving particles makes all order in nature a temporary effect, renders nature as a whole a mere aggregate, and provides no meaning for continuity as a primary factor or for the field as a causal factor. The Greek conception, as formulated, either in mathematics and astronomy by Plato and Eudoxus, or in biology by Aristotle, does justice to the continuity and unity and organization, and to the field character of natural phenomena, at the cost of interpreting nature as a single substance or system and rendering change, atomicity, and the temporal origin of species meaningless. It is clear, therefore, that before the doctrine of reciprocal causal interaction between particle and field can possess meaningful, consistent theoretical formulation a new theory of the first principles of science must be developed. Moreover, this new theory must combine the Greek and Modern conceptions of science which have previously been supposed to be incompatible.

It is essential that the reader sense the necessity of this theoretical formulation before going further. Otherwise the electro-dynamic theory of life proposed in this paper will appear as but a new name for traditional conceptions, and its essential novelty and significance will be missed. This point may be made by referring to an experience which the authors of this paper had when the theory, proposed here, was presented to an experimental anatomist. He replied, "Yes, the field theory of life is reasonable, but what is the field except as it is determined by its physico-chemical constituents?" In this query he gave expression to the funda-

mental presupposition of traditional modern science, that the field, or nature as a whole, is a mere aggregate of the atomic parts and in no sense a primary causal factor. He was quite right also in suggesting that the field theory of life would be but a new name for old commonplaces were this all that it means. The point is, however, that the theory which we are proposing means more than this. The microscopic physico-chemical constituents do determine the character of the field. No one cognizant of modern physics and physiological chemistry can deny this. But this relation between field and particle is not, as traditional modern scientific theory has assumed, an asymmetrical or one-way relation. The field both determines and is determined by the particle. But to find meaning for the field as, in this partial sense, an ultimate causal factor is the real difficulty. In the traditional modern scientific conception of nature as a collection of particles in motion and physico-chemical interaction, there is no meaning to the field as anything more than a mere aggregate and effect of their compounding; in Newton's physics, given the masses with their inertial and accelerative forces, the gravitational field and the orbits are completely determined. To make sense out of the notion that the field determines the behavior of any local process or constituent within it, it is necessary to modify modern science at its very foundations by revising our theory of first principles to provide meaning for the unity of nature as a causal factor. Without this revision in our most elemental and fundamental conception of nature as conceived by science, all field theories whether in physiology or physics are mere verbiage.

It is easy enough to find meaning for the unity of nature, and for the field as a causal factor providing we return to that

Greek conception of science which makes continuity ultimate, regards nature as one substance, and interprets all plurality as a mere abstraction from the unity. But this is to go to the other extreme and find meaning for the causal efficacy of the field at the cost of denying all determination of the field by the particle. Clearly, modern science will not permit us to do this. It is impossible now to deny the validity of physico-chemical categories. There is the particle as well as the field. It is clear, therefore, that meaning for the field and the unity of nature as a causal factor must be gained without rejecting the primacy of the atomic physico-chemical categories of modern science. The only completely physical theory of the first principles of science proposed to date which accomplishes this is the macroscopic atomic theory developed by one of the authors of this paper (Northrop, 1928, 1931). It retains the kinetic atomic theory of traditional modern science, thereby providing theoretical foundations for the physico-chemical categories which modern investigations have established, and providing meaning for the determination of the field by the particle. To this traditional kinetic atomic theory it adds one macroscopic atom which surrounds and, *solely because of its relatively small fixed finite size*, compresses and congests the microscopic particles, of the whole of nature, of traditional theory, which it contains. Thus a unity of nature as a whole is impressed upon the compounding and aggregating of the microscopic particles to make complex nature one as well as many, a unity as well as an aggregate, a field which in part determines the behavior of each particle and process, as well as a complex continuum, in part constituted by the motion and interaction of the particles. Whether the macroscopic atomic theory will gain confirmation directly by further

empirical investigations need not concern us here. Its mere existence as a possible theory is sufficient for our present purposes, since this demonstrates that it is possible to combine the Greek scientific conceptions of nature as a single system with the modern scientific conception of nature as an aggregate of many particles, without contradiction, and thereby gives meaningful formulation to the thesis that the particle in its behavior both determines and is determined by the field in which it is embedded.

Having demonstrated that the doctrine of the reciprocal interaction between field and particle can be given consistent meaningful theoretical formulation, it remains to designate the evidence in both physics and biology which supports it, and the modification in our attitude toward all systems in nature, which its acceptance must entail.

The first conclusive evidence in physics of the necessity of supplementing atomic physics with field physics appeared in the relativity theory. A short survey of certain developments in the history of science will make this clear. Science has always distinguished between two types of structure or relatedness in nature. The one type, most evident in space, is relatively constant through time; the other, evident in the obvious changing relations between things, is subject to change with time. Actually both types of structure or relatedness apply to the physical content of the universe, but Newtonian physics did not view the situation in this light. Instead, it separated the relatively constant spatial structure of physical nature from the physical content and turned the separated structure into an independent entity called absolute space. This space was really a field, but since it permitted matter to move through it without opposition there was little or no meaning to

the statement that the field conditioned the behavior of the particle. A similar separation and reification of the field character of physical nature occurred in the sciences of optics and electricity with the introduction of the ether. The theory of relativity has demonstrated, however, that this entire procedure is mistaken. In doing away with the independent ether, and in merging matter and space and time, Einstein has shown that the approximately constant macroscopic structure of space is the approximately constant macroscopic structure of matter itself. The field is not independent of matter but a very condition for and causal determiner of the behavior of matter. Thus Einstein replaces Newton's three laws of motion with the single law that a body moves in a path which is a geodesic of the space-time of the observer's frame of reference. But the general theory of relativity also prescribes that the distribution of matter determines the character of the metrical field, and thereby the lay of the geodesic. Thus the particle both conditions, and is conditioned by, the metrical field.

These considerations from the verified general theory of relativity are sufficient to indicate that the attempt to conceive of nature entirely in terms of the pluralistic discontinuous microscopic atomic physico-chemical categories of traditional scientific thought is inadequate. This does not mean that these traditional categories are invalid; they are in fact necessary, as the general theory of relativity indicates when it makes the metrical properties of space dependent upon them and their distribution, but they are nevertheless insufficient. The field also conditions the behavior of the particle.

The second evidence in physics for the theory of the reciprocal determination of particle and field appears in wave mechanics. At this point the relevance of

all this for biology can be made more direct and explicit. Biologists have discovered that whatever else living creatures may be they are in a very real and significant sense physico-chemical systems. But chemists and physicists have now conclusively demonstrated that the electro-dynamic theory of nature is more fundamental than the chemical theory. The reduction of the chemical atom to electrons and protons and the development of quantum theory and wave mechanics implies this. Moreover, the recent surprising tendency in wave mechanics is to put the emphasis on the field even to the point at times of attempting to derive the particle from it. This, as Darrow and G. P. Thomson have pointed out (Darrow, 1927; Thomson, 1932), is an error; moreover, quantum physics reveals even new evidences of discontinuity. Nevertheless, the fact still remains that the field as a distinctly causal factor is indispensable.

These established and accepted findings of contemporary physics are sufficient to indicate that the same influence from the mature science of physics, which previously drove biology with Harvey to the mechanical theory of living creatures, and with Lavoisier to the chemical theory of their nature, must now drive us to an electro-dynamic theory of life. Contemporary developments in physics rest upon the discovery of the primacy of electro-dynamic theory over chemical or traditional physical theory.

Moreover, and this is the crucial point, this shift involves much more than a mere shift in terms. Contemporary physics has gone very much further than the mere statement of chemical elements in terms of electrons and protons. The latter advance, while of great importance, still involves the traditional emphasis solely on entities and their motion. The

current shift is much more fundamental than this, for the field as well as the particle is now revealed as a causal factor. Once this point is really grasped our whole attitude towards our scientific knowledge must change. Structure again becomes significant. It is no longer permissible to assume, as traditional modern science has done, that if the constituent chemical components are determined the field and the structure will take care of itself.

The significance of this for biology can be made evident by a brief consideration of its most fundamental and perplexing problem—the problem of organization. It is a commonplace that living creatures, notwithstanding the modification in types in evolution, maintain a certain constancy of structure through continuous changes of material. Aristotle with his doctrine of form as well as material causes provided a theoretical basis for this fact, but failed to account for the mutability of species. Modern science with its rediscovery of the kinetic atomic theory and its attendant doctrine of the variability of structure with motion, provided meaning for Darwin's discovery, and the physico-chemical nature of life, but at the cost, as Claude Bernard indicated, and as Driesch and J. S. Haldane have emphasized more recently, of failing to do adequate justice to the relative constancy of biological organization. The traditional modern doctrine that the chemical elements completely condition the structure and organization of the organism failed to explain why a certain structural constancy persisted through the chemical flux.

This obvious inadequacy led to the introduction of non-physical factors such as *Driesch's* "entelechy," *Spemann's* "organizer," *Rignano's* "biological energy," *Child's* "physiological gradient," *Weiss's* "biological field," and *Köbler's* "Ges-talten," all of which have certain validity

as descriptive terms. It now appears, however, that the difficulty may have its basis, not in the failure of any possible physical theory, but in the inadequacy of traditional physical theory. For the chemical view with its emphasis on entities has been demonstrated to reduce to the electro-dynamic view in which the more constant structural guiding contribution of the field is found to supplement the contingent changing relatedness introduced by the motion of the particles.

If this new electro-dynamic theory is correct it follows that biological science must supplement its present emphasis on chemical analysis and on entities with a more serious study, by the experimental determination of potential distribution, of field factors, and structure and organization in itself. It appears also that biology itself suggests the necessity of the particle-field theory.

II. BIOLOGICAL AND NEUROLOGICAL CONSIDERATIONS

The necessity is apparent when an attempt is made to unravel the underlying processes inherent in ontogeny. In spite of the mass of accumulated data concerning the development of the organism in general and of the nervous system in particular, no thoroughly satisfactory explanation has been given of the regulation and control of growth. Description of successive steps of development in a wide variety of forms reveals little of the relationships which exist between the steps or the factors which regulate the passage from one to the other. The very wealth of the accumulated facts tends to obscure the underlying regulation and to defy analysis. It was this difficulty which led Driesch to the repostulation of a "vital force" or entelechy. This brilliant hypothesis has never received its just due. The whole theory is a very adequate

description of an extraordinarily constant control and regulation of growth. Its weakness lay in its assumption of an extra-biological agent incapable of scientific description. The field theories of Spemann, Weiss and Gurwitsch are also valuable attempts at explanation, but like the entelechies of Driesch, scientific analysis is wellnigh impossible.

All embryologists have been impressed at one time or another with one aspect of the problem noted above. Growing systems possess an extraordinary capacity for self-regulation. Some powerful agent seems to be inherent in the system through which the progress of development from stage to stage is coördinated and regulated according to a definite plan. Each and every biological system seems to possess a dynamic "wholeness" the maintenance of whose integrity is a necessity of continued organic existence. Virtually all the theoretical analyses stress this quality but no adequate definition of this dynamic agent or adequate explanation of its working has been offered.

Not only is the regulation in ontogeny an enigma, but we are still almost completely ignorant of the dynamic relationships in living systems. A considerable body of information is available concerning the physical and chemical structure of protoplasm but we know little of the way in which the elements are organized into a dynamic whole. The cytoplasm of a living cell is not a formless agglomeration of chemical substances but is an integrated and coördinated system. It is impossible to conceive of cytoplasm as a haphazard arrangement of molecules. A definite pattern of relationships must exist. We possess a modicum of knowledge of these relationships at any one moment but we have no adequate theory of the mechanism which maintains that pattern throughout the rapidly changing flux in

living systems. Study of the situation in the nucleus is somewhat more advanced because of the greater definiteness of the formed elements. We possess fairly clear statements of the physical and to some extent of the chemical components of the nucleus. The dynamic activities of the formed elements, the chromosomes, have been partially unravelled by geneticists. As in cytoplasm however, we lack any adequate hypothesis of the mechanisms involved in chromosomal aggregations or in the splitting and distribution of the component elements. The results of the processes have been widely studied and have provided an important body of information but we still lack understanding as to how the results are accomplished. Here then, as in embryology, we find "pattern of organization" the fundamental problem.

The difficulties suggested above are no less apparent in the analysis of the development of the nervous system. The successive steps have been described by innumerable workers but we lack any rational explanation of the appearance of local regions of growth and differentiation and of the final establishment of nuclear masses and fiber tract pathways. Although Spemann has shown the importance of the dorsal lip of the blastopore as a concomitant of the formation of the nervous system, there is little understanding of the factors involved in this relationship. Moreover, neither fact nor theory has yet made clear the nature of the factors which give this power to the dorsal lip of the blastopore.

Careful consideration of the many facts of which the above is but a suggestive résumé, compels us to look for an hypothesis which will cover not only the dynamics of development but also the pattern of organization of unitary biological systems. The search for such an

hypothesis has intrigued many investigators. As has been shown earlier in this paper, its formulation has been hindered by reliance upon earlier physical theory. With the advent in physics of the field theory of the relationships between particulate matter, the resolution of the biological theory becomes clearer. It is believed that the theory about to be proposed satisfies this condition and if it can be demonstrated, gives the solution to many problems of biology.

The theory is the result of many years of experimental investigation of the mechanisms involved in the development of the nervous system (Cf. Burr, H. S., 1916a, 1916b, 1920, 1924, 1926, 1930, 1932). In these studies it has been shown (Burr, 1932) that an extremely important factor in the organization of the nervous system is the rise and fall of differential growth rates within the wall of the neural tube. Moreover, experimental work confirms the belief that the direction of growth and the end station of differentiating nerve fibers is related to these primary centers of rapid proliferation. Inasmuch as they seem to be potent factors in imparting the fiber pattern to the nervous system, it becomes necessary to inquire into the agents which could act to determine the locus of these areas and to regulate the division rates in them. If this could be settled then it would be possible to formulate an hypothesis as to the origin of pattern in the nervous system. Conceivably this might provide a clue to the origin of pattern in developing organisms and in other living systems.

An increasing body of evidence (Gurwitsch, 1926; Ingvar, 1920; Lund, 1922) indicates that bio-electric phenomena underlie growth as well as many other biological processes. Numerous electrometric studies compel us to believe in the presence of polar and potential differences

in living systems. If this is true it follows by definition that electro-dynamic fields are also present. Their existence in the physical world is generally accepted. Moreover, the formed relations of particulate matter is to a considerable degree a function of such fields. Thus the individual characteristics of atomic matter are a result of the interdependence of fields and particles. Pattern in physics, then, is determined by the interplay of electro-dynamic fields and the particular matter therein contained.

It is reasonable to extend this hypothesis into the realm of biology. Potential gradients and polar differences exist in living systems. If this is so, then electro-dynamic fields are also present. The following theory may therefore be formulated. The pattern or organization of any biological system is established by a complex electro-dynamic field, which is in part determined by its atomic physico-chemical components and which in part determines the behavior and orientation of those components. This field is electrical in the physical sense and by its properties it relates the entities of the biological system in a characteristic pattern and is itself in part a result of the existence of those entities. It determines and is determined by the components. More than establishing pattern, it must maintain pattern in the midst of a physico-chemical flux. Therefore, it must regulate and control living things, it must be the mechanism the outcome of whose activity is "wholeness," organization and continuity. The electro-dynamic field then is comparable to the entelechy of Driesch, the embryonic field of Spemann, the biological field of Weiss.

The implication of the above theory for embryology yields a number of interesting points only one of which can be considered here. An intriguing problem in

chordate development is the establishment of a longitudinal axis. This is a very real structural alignment although at early stages in development the cells which are related to it may be toti-potent. Experimental rearrangement of the cellular units does not change the axis although they themselves may have their ultimate fate altered. Caudal cells may become cephalic cells, right cells may become left with little serious interference with the normal processes of growth. Yet in some way the constituent cells of the growing system have their fate determined and their behavior and orientation controlled.

At least two factors in this regulation are familiar. Embryology and genetics have given adequate evidence of the importance of the chromosomes in determining cellular fate. The investigations of Weismann, Driesch, Boveri, Hertwig and many others attest this. The geneticists have confirmed it and we are compelled to believe that the formed elements in the nucleus partly determine the growth and differentiation of cells. But the experimental embryologists have shown that intercellular relationships are no less important. Spemann and his students have demonstrated the dependence of cells on their local environment. The induction or organization hypothesis is an expression of their findings. To genetic constitution, then, there must be added local cellular environment as an important determiner of cell fate and therefore of the organization of the growing systems.

To Driesch, however, we owe the brilliant observation that the fate of any group of cells in an embryo is not only genetically conditioned but is also a function of the position of that group in the whole biological system. The mechanism by which position could determine cellular potencies was explained by Driesch through the assumption of an

extra-biological guiding principle, an entelechey. It is at this point that the electro-dynamic field theory proposed above provides a significant explanation of the well recognized facts. In the physical world the nature of an atom is dependent upon the number of entities which comprise it and the field in which they lie, the position of the electron orbits being of fundamental importance. So, on a very much more complex scale in a biological system the fate of any group of cells is determined in part by the position those cells occupy in the electro-dynamic field of the embryo. It is clear that if the above be granted three factors are present in the normal development of an organism. The cells must possess a certain genetic constitution, a certain cellular environment and a certain position in an electro-dynamic field.

This is not the place to extend the application of the theory to many other problems of embryology for another important aspect calls for attention. The pattern of the organization of the molecular and atomic constituents of protoplasm is an even more important problem to biology than the physico-chemical nature of the entities themselves. It is not enough to know the chemical formula of protoplasm. It is of vital importance to understand how the elements are related to each other, how they are gathered together in a single "whole" system. If the electro-dynamic theory is sound the characteristic relationship of the elements of any biological system is a function of the field of the system. If this be true then the great jump from living organic matter to non-living physical matter is no longer inexplicable. The difference between the two is to be found in all probability in more complex fields and more complex molecular structure. Life, then, is not a special creation but an expression

of fundamental law operating in living and non-living matter alike.

The theoretical considerations here presented have led us to the conclusion reached by nearly all other investigators, that pattern or organization is a fundamental characteristic of biological systems, or of physical systems, or of the universe. The electro-dynamic theory provides a working hypothesis for a direct attack upon this problem. If accepted, it opens up a wide field of study based upon electrometric methods. It should be possible, therefore, to determine by objective experiment whether or not such fields exist. In other words, this theory can be put to experimental test. Finally the theory makes it possible to place the investigation of the organization of living systems on the same objective and physical basis as the analysis of their chemical constituents.

It appears, therefore, that an hypothesis of this type is necessary to bring biological theory into line with physical theory. Moreover, biological considerations alone

affirm a similar necessity and provide a sufficient amount of data to warrant putting to Nature, by experimental and electrometric methods, the questions which this theory raises. These questions fall naturally into three categories. In the first of these are to be found questions as to the presence and character of potential and polar differences in living organisms. In the second are the questions dealing with the measurement of electro-dynamic fields as concomitants of the potential differences. In the third are those questions which are associated with the impact of an altered field in the environment on developing mechanisms. In all probability new technical methods will have to be devised before definite answers can be obtained. Furthermore, if the theory is established, it makes possible the application of the mathematical methods being developed for field and wave physics to biological material, thereby placing the study of biological organization on a mathematical as well as an experimental basis.

LIST OF LITERATURE

- BURN, H. S. 1916a. The effects of the removal of the nasal pits in *Amblystoma* embryos. *Jour. Exp. Zool.*, vol. 20, no. 2, p. 27.
- . 1916b. Regeneration in the brain of *Amblystoma*. *Jour. Comp. Neur.*, vol. 26, no. 2, April, p. 203.
- . 1920. Transplantation of the cerebral hemispheres of *Amblystoma*. *Jour. Exp. Zool.*, vol. 30, no. 1, p. 159.
- . 1924. Some experiments on the transplantation of the olfactory placode in *Amblystoma*. *Jour. Comp. Neur.*, vol. 37, no. 3, October, p. 455.
- . 1930. Hyperplasia in the brain of *Amblystoma*. *Jour. Exp. Zool.*, vol. 55, p. 171.
- . 1932. An electro-dynamic theory of development. *Jour. Comp. Neur.*, vol. 56, p. 347.
- BURN, H. S., and MARION E. SNAVELY. 1926. An experimental study of the action of hyoscine hydrobromide on the development of the nervous system of *Amblystoma*. *Jour. Comp. Neur.*, vol. 41, no. 1, p. 401.
- CHELL, C. M. 1924. Physiological Foundations of Behaviour. New York.
- DARROW, K. 1927. Introduction to wave mechanics. *Bell Telephone Laboratory Reprints* B 273, p. 49.
- DRIESCH, H. 1908. The Science and Philosophy of the Organism. London.
- EINSTEIN, A., and others. 1923. The Principle of Relativity. London.
- FREUNDLICH, E. 1933. Die gegenwärtige Anschauung vom Aufbau des Weltgebäudes. *Die Naturwissenschaften*, Heft 5, 6, 7, pp. 86-94.
- GURWITSCH, A. 1922. Über den Begriff des embryonalen Feldes. *Roux Arch.*, LI.
- INGVAR, S. 1920. Reaction of cells to galvanic current in tissue cultures. *Proc. Soc. Exp. Biol. and Med.*, vol. 17, p. 198.
- KÖHLER, W. 1929. Gestalt Psychology. New York.
- LUND, E. J. 1922. Experimental control of organic polarity by the electric current. II. The normal electrical polarity of *Obelia*. A proof of its existence. *Jour. Exp. Zool.*, vol. 36, no. 4, p. 477.
- . 1925. Experimental control of organic polarity by the electric current. V. The nature

- of the control of organic polarity by the electric current. *Jour. Exp. Zool.*, vol. 41, no. 2, p. 155.
- LUND, E. J. 1928. Relation between continuous bioelectric currents and cell respiration. II. *Jour. Exp. Zool.*, vol. 51, no. 3, p. 265.
- NORTHBROP, F. S. C. 1928. The macroscopic atomic theory. *Jour. Phil.*, vol. XXV, p. 449.
- . 1931. *Science and First Principles*. New York.
- RIGNANO, E. 1926. *Qu'est-ce que la Vie?* Paris.
- SPEMANN, H. 1927. Organizers in animal behavior. *Proc. Royal Soc. London, Ser. B*, 102, p. 177.
- THOMSON, G. P. 1932. Electron optics. *Nature*, vol. 129, p. 81.
- WEISS, P. 1927. Morphodynamische Feldtheorie und Genetik. *Verh. des V. Intr. Kongr. für Vererbungswissenschaft*. Berlin.





THE ALL-OR-NONE PRINCIPLE AND THE NERVE EFFECTOR SYSTEMS

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THE all-or-none principle states that there is an all-or-none *relation* between the stimulus and the response which it sets up (Bowditch, 1871; Adrian, 1931). As pointed out by Adrian (1914), this all-or-none relation is a necessary consequence of the coexistence of the following three conditions in the excitable structure: a threshold, an absolute refractory period and a conduction of the excited state over the whole structure so that it behaves as a single unit. If any one of the three conditions stated is lacking, the response will not be all-or-none (quantal).

WHAT IS MEANT BY "STIMULUS"?

A great deal of discussion about the validity of the all-or-none principle in different systems would be avoided if the terms stimulus and response were precisely defined. The usual convention is to designate as stimulus the external agent applied by the experimenter and to call a response any active change in the tissue elicited by this agent. Since there are frequently several intermediate steps between the stimulus and the ultimate response, it is obvious that any analysis which disregards these intermediate steps will be incomplete, and therefore fallacious.

Suppose an electric shock is applied to an autonomic nerve supplying a smooth muscle. The electric shock (stimulus) produces in the nerve a local excitatory state, which is passive and which we therefore do not call a response. If this

local excitatory state reaches a threshold value a nerve impulse ensues, which is the response of the nerve to the stimulus. This impulse, on reaching the muscle, behaves now as a stimulus and evokes an electric potential (initial potential, Rosenblueth, Leese and Lambert, 1933) and the liberation of a certain amount of a chemical mediator (see Cannon, 1933). We do not know the relations existing between the initial potential and the chemical mediator, but we may assume provisionally that the potential precedes the liberation of the mediator and stimulates the production of the latter (see below). The mediator, a response to the conducted disturbance in the muscle, now combines with the receptive substance and the compound thus formed stimulates the contractile mechanism (Rosenblueth, 1932b), so that a final contractile response ensues.

As pointed out by Adrian (1922), if there is any all-or-none step in such a series, it will necessarily impose an all-or-none relation between a single stimulus and the final response of a single element. An observation establishing such a quantal relation will not give any information as to whether there is more than one all-or-none step, where this quantal step or steps occur, and whether there are any graded processes involved. Direct stimulation of muscle (Pratt and Eisenberger, 1919; Bozler, 1927, 1928 and 1931; etc.) is, therefore, preferable to the stimulation of the nerve supply (Lucas, 1909), when investigating the all-or-none characteristics of the former.

WHAT IS MEANT BY "MUSCLE"?

Even direct stimulation of muscle is not, however, sufficiently discriminating. "Muscle" is a term which belongs to gross anatomy. The microscope reveals not only muscle fibers but a very complex structure in the muscle fiber. Physiologically the striped muscle fiber presents at least two features, a conducting and a contracting system. In smooth muscle there are at least three processes: the production of the mediator (see Cannon, 1933), its combination with the receptive substance (Cannon and Rosenblueth, 1933) and the contraction. A thorough knowledge of the quantal processes in either striped or smooth muscle requires a discrimination between the successive steps as to all-or-none or graded behavior.

Pratt and Eisenberger (*loc. cit.*) found a quantal response of striped muscle to direct electrical stimulation. Graded responses may, however, be obtained, as shown by Fischl and Kahn (1928), Gelfan (1930) and Asmussen (1932). From these conflicting results we should be led to the quite unilluminating conclusion that there may or may not be an all-or-none relation between the electric stimulus and the muscular response. The obscurity disappears, however, when we take account of the intermediate steps, for, as reported by Gelfan and Bishop (1932), the graded responses are obtained when the stimulus skips the conducted disturbance and acts beyond, presumably on the contractile system itself.

The indiscriminate use of the term "stimulus" is confusing when applied only to the first link of a chain of events functionally related. The real stimulus to a given reaction is the event which immediately precedes it and of which the reaction is a direct consequence. Thus, in autonomic effectors the real stimulus

for the final specific response implied by the term effector is not the electric shock, nor the nerve impulse, nor the initial potential in the effector, but the compound formed by the combination of the mediator with the receptive substance. Our analysis of the applicability of the all-or-none principle to neuro-effector systems will consist in an examination of the relations between each step and the succeeding one in the series of functionally related phenomena which begin at the peripheral efferent nerve and end with the specific reaction of the effector. The problem, then, is to determine, in view of the evidence available, whether there is a quantal or a graded process at each of the consecutive links in this chain of events, and to ascertain what links are activated by our experimental means of excitation.

THE CHAIN OF EVENTS IN EXCITATION

According to the data available, the following is the sequence of functionally related events which probably occur in the electrical excitation of a neuro-effector system: 1) electric shock → 2) local excitatory state in nerve → 3) nerve impulse (conducted disturbance in nerve) → 4) local excitatory state in neuro-effector junction → 5) conducted disturbance in the effector → 6) liberation of mediator → 7) combination of mediator with receptive substance → 8) specific reaction of the effector (contraction or relaxation of muscle, acceleration or deceleration of the heart, secretion, etc.).

We shall first examine the evidence which leads us to postulate the existence of the links in the above chain of events that are not generally recognized; we shall then consider at what links the chain may be activated by the physiological and by certain experimental stimuli, or blocked by some paralyzing drugs; and we shall

finally point out some of the implications of the views adopted.

The fourth link (4, in the series) is postulated to cover the cases of peripheral summation of nerve impulses. This summation of nerve impulses is known to occur in striped muscle (Lucas, 1917a and b; Bremer and Homès, 1931). It would also occur in autonomic systems if some of them should be "iterative," in the sense of Lapicque and Meyerson (1912). The expression "local excitatory state," used in analogy to the corresponding phenomenon in nerve, is meant to be quite non-committal as to the nature of the process involved. Adrian and Lucas (1912) offered the explanation that a second impulse succeeds in stimulating the muscle, while the first one fails, because the second one appears during the super-normal phase of recovery from the first, and is therefore better conducted. This explanation was based on the idea that decremental conduction occurred at the junctional region (see Adrian, 1920). Adrian (1920) showed, however, that the super-normal phase occurs only at a pH which is improbable in highly buffered physiological systems. Furthermore, conduction with decrement is also quite improbable (Kato, 1924; Davis, Forbes, Brunswick and Hopkins, 1926). We must, therefore, seek for another explanation.

Assuming the membrane theory, since a nerve impulse can reach the muscle and stop without eliciting a conducted disturbance in the muscle, it is obvious that there is a discontinuity between the two polarized interfaces responsible for the conducted disturbances. If the successive nerve impulses are of equal intensity, as is probable, it is reasonable to assume that each one leaves an effect at the junction of the nerve with the muscular polarized interface and that succeeding

nerve impulses add their effects to those remaining from the preceding impulses until a threshold is attained and the conducted disturbance of muscle is originated. It is to these additive effects at the neuro-effector junction that we apply the expression local excitatory state.

It is possible that link 5 does not exist in some autonomic effectors. Thus Rosenblueth, Leese and Lambert (1933) failed to find any evidence of an initial potential in the pregnant uterus excited through the hypogastric nerves; and Rosenblueth, Forbes and Lambert (1933) concluded that the potentials recorded from the submaxillary gland were probably correlated with the chemical changes involved in the responses, and not with the excitatory process.

The spike potential of striped muscle is generally recognized to be associated with the process of *conduction* of excitation throughout the muscle fiber. Such a process is superfluous in autonomic systems since the effector cells are small, and the mediator diffuses freely from cell to cell (Rosenblueth and Rioch, 1933). There is no quantal wave of excitation transmitted from cell to cell as in cardiac muscle (Rosenblueth and Rioch, *loc. cit.*). In view of these reasons, it is possible that the initial potential of smooth muscle (Rosenblueth, Leese and Lambert, *loc. cit.*) may not be strictly analogous to the spike potential of the conducted disturbance of striped muscle. Until more evidence is available, however, it is perhaps safer to assume this analogy.

The evidence for the existence of the chemical mediator (link 6) has been obtained from autonomic systems (see Cannon, 1933, for references). We assume, however, that there is probably a chemical mediation in striped muscle likewise, because a chemical theory is the most satisfactory explanation for the phenom-

enon of summation of contraction (Rosenblueth, 1932b), and for peripheral inhibition (see below) such as that which appears in the striped muscle of the claw of arthropods; also because the analogy with what occurs in smooth muscle is legitimate until proof to the contrary is presented; and finally, because no known fact contradicts this hypothesis (Rosenblueth and Rioch, *loc. cit.*).

Link 7 is postulated to account for the relations existing between degree of stimulation (nervous or chemical) and response (Rosenblueth, 1932a and b), and to explain peripheral inhibition (Cannon and Rosenblueth, 1933).

It is probable that some of these steps are skipped in some systems. We indicated above that a conducted disturbance may not exist in some autonomic effectors. In the adrenal medulla the mediator, as shown by Feldberg, Minz and Tsudzimura (1933), is acetylcholine. Since the output of adrenin is a linear function of the frequency of splanchnic stimulation (Rosenblueth, 1932b), it is reasonable to assume that acetylcholine acts here directly on the effector, without any previous combination with a receptive substance—i.e., step 7 is absent in this system. In all other systems studied the responses are hyperbolic, not linear, functions of the frequencies of parasympathetic stimulation (Rosenblueth, 1932b) and of the doses of acetylcholine (Clark, 1926).

Adrenin and acetylcholine act on autonomic systems at link 7, as demonstrated by the lack of initial potentials (Rosenblueth, Leese and Lambert, *loc. cit.*). This is in accord with the fact that they are in all probability identical with the mediators postulated in link 6 for autonomic systems (see Cannon, 1933).

The electric stimulus is capable of activating the conducted disturbances 3

and 5 as befits the now generally accepted idea that the propagation of the conducted disturbance is related to the electric phenomenon which accompanies it. Electricity has also some direct effects on the contractile system of muscle (link 8), both striped and smooth (see Rosenblueth and Cannon, 1934, for references). These effects are, however, very small when compared to the contractions obtained when link 5 is affected. Electricity, on the other hand, probably has no direct effects on the secretory system of glands; certainly this is true if we may take as an example the denervated adrenal medulla, which is electrically inexcitable (Rosenblueth and Cannon, 1934).

Ergotoxine blocks sympathetic excitatory impulses beyond link 7, at the effector system proper itself, since the conducted disturbances in the effectors persist (Rosenblueth, Leese and Lambert, *loc. cit.*), the mediator is still produced (Cannon and Bacq, 1931), and the combination of the mediator and the receptive substance still occurs (Cannon and Rosenblueth, 1933). Atropine probably exerts its paralyzing effects at the same level, since the mediator is likewise still produced (Loewi, 1922).

Curare probably blocks the sequence for striped muscle at link 4, as shown by Claude Bernard (1854). Lapique (1926) suggested that curare acts by increasing the chronaxie of muscle—i.e., at link 5. Grundfest (1932) and Rushton (1933) have brought forward evidence, however, that the muscular chronaxie is unaffected.

The only two links known to be quantal, whatever the means employed to activate them, are links 3 and 5, the conducted disturbances. The proof of their all-or-none character is complete (see Ritchie, 1932, and Adrian, 1933).

Our lack of knowledge of the relations existing between links 5 and 6 in smooth

muscle (see above) does not permit us to qualify the behavior of the latter with respect to the all-or-none principle.

The evidence presented by Davis and Davis (1932), showing that in striped muscle the tension varies as the magnitude of the spike potential, is in favor, however, of the view that 6 is a graded function of 5.

Link 7 is not a quantal step; it follows the law of mass action (Rosenblueth, 1932a and b). Link 8, finally, is a graded linear function of the concentrations of the compounds formed in link 7 (Rosenblueth, 1932a and b). The effector system proper does not follow, therefore, the all-or-none principle.

CONDUCTION IS QUANTAL; EXCITATION IS GRADED

In so far, then, as it is legitimate to separate conduction from excitation, and the schema and evidence presented justify this separation, conduction is quantal while excitation is graded. Thus adrenin and acetylcholine, which excite without conduction, elicit exclusively graded responses. Any investigation which includes either of the two quantal processes of conduction, 3 and 5, may reveal an all-or-none relation between stimulus and response. Indeed, if one deals with elements (single nerves or effectors) the quantal type of response will invariably appear (Lucas, 1909; Adrian, 1914; Pratt and Eisenberger, 1919; Adrian, 1922; Bozler, 1927, 1928, 1931; etc.). Experiments may be devised, however, which, although including the quantal steps, reveal the graded links. Thus, the results of Rosenblueth and Rioch (*loc. cit.*) do not follow the all-or-none principle. These results are the following: after a large fraction (e.g., 5/6) of the nerve supply to an autonomic effector has been destroyed, the mechanical responses to high fre-

quencies of stimulation (e.g., 20 per second) of the remaining nerves tend to become equal to those obtained by the same high frequencies before the nerve supply was impaired, while the responses to low frequencies (e.g., 1 per second) are considerably decreased. If the mode of excitation of the effector were exclusively all-or-none (i.e., if there were no graded steps) a constant fraction of the original responses would be obtained at any frequency. There is some mechanism in play by which any nerve fiber may influence a large proportion of the elements of the effector, and this mechanism is graded. An adequate explanation is that there occurs a free diffusion of the mediator from cell to cell, unlike what happens in striped muscle.

From the physiological standpoint, the specific reactions of the effectors are usually elicited by quantal nerve impulses, whose number varies temporally or spatially. The interposition of the chemical mediation tends to convert this intermittent, quantal mode of excitation into a continuous, graded process. In autonomic effectors the gradation and continuity are still further emphasized by the free diffusion of the mediator. In effectors supplied by the sympathetic an exclusively graded mode of stimulation occurs when adrenin is secreted into the blood stream.

The free diffusion of the mediator in all autonomic systems and the activation of sympathetic systems by means of adrenin decrease considerably the possibility of spatial localization of the responses in the corresponding effectors. The lack of diffusion in skeletal muscle, on the contrary, favors this localization. This difference in the mode of activation of striped and smooth muscle is in keeping with their functions: precise movement of the former and diffuse action of the latter.

There is some evidence pertinent to the

subject which has not been included in this discussion Gelfan and Bishop (1933) observed conducted contractures without action potentials on mechanical stimulation of single striped muscle fibers of the retrolingual membrane of the frog The necessary conclusion is that there is some other possible mechanism of conduction than the known wave of depolarization It is impossible to decide at present whether this other mechanism has any physiological significance.

A broader generalization, which would include the central nervous system, is

desirable Although a similar schema may serve as a help for the study of the transmission of impulses in the central nervous system, it is premature at present to attempt an inclusive generalization

Obviously, link 8, the specific reaction of the effector, is in itself a complex process But this process will be different in different effectors, and elude a general treatment The schema presented attempts to cover only conduction and excitation We find these processes complex, but probably fundamentally identical in very different structures.

LIST OF LITERATURE

- ADRIAN, E D 1914 The all-or none principle in nerve *Journ Physiol*, 47 460-474
- 1920 The recovery process of excitable tissues *Ibid*, 54 1-31
- 1922 The relation between the stimulus and the electric response in a single muscle fibre *Arch Neer de Physiol*, 7 330-332
- 1931 The messages in sensory nerve fibres and their interpretation *Proc Roy Soc B*, 109 1-18
- 1933 The all or nothing reaction *Ergeb d Physiol u Exp Pharmac*, 35 744-755
- ADRIAN, E D, and K LUCAS 1912 On the summation of propagated disturbances in nerve and muscle *Jour Physiol*, 44 68-124
- ASMUSSEN, E 1932 Über die Reaktion isolierter Muskelfasern auf direkte Reize *Pfluger s Arch*, 230 263-272
- BERNARD, CLAUDE 1854 Leçons de Physiologie Experimentale *Paris*
- BOWDITCH, H P 1871 Über die Eigenthümlichkeiten der Reizbarkeit, welche die Muskelfasern des Herzens zeigen *Berichte d Königl Sächs d Ges d Wissen*, 23 652-689
- BOZLER, E 1927 Untersuchungen an den Muskelfasern von Beroe *Zeitschr f vergl Physiol*, 6 361-377
- 1928 Die Chromatophoren-muskeln der Cephalopoden *Ibid*, 7 379-406
- 1931 Registrierung der Kontraktionen der Chromatophoren-muskelzellen von Cephalopoden *Ibid*, 13 762-772
- BREMER, F, and G HOMM 1931 Une théorie de la sommation d influx nerveux *Mém Acad Roy Belg*, 11 3-31
- CANNON, W B 1933 Chemical mediators of autonomic nerve impulses *Science*, 78 43-48
- CANNON, W B, and Z M BACQ 1931 A hormone produced by sympathetic action on smooth muscle *Am Journ Physiol*, 96 392-412
- CANNON, W B, and A ROSENBLUTH 1933 Sympathin E and sympathin I *Ibid*, 104 557-574
- CLARK, A J 1926 The reaction between acetylcholine and muscle cells *Journ Physiol*, 61 530-546
- DAVIS, H, and P A DAVIS 1932 Fatigue in Skeletal muscle in relation to frequency of stimulation *Am Journ Physiol*, 101 339-356
- DAVIS, H, A FORBES, D BRUNSWICK and A HOPKINS 1926 Studies on the nerve impulse II The question of decrement *Ibid*, 76 448-471
- FELDBERG, W, B MINZ and H TZUDZIMURA 1933 The mechanism of the nervous discharge of adrenaline *Journ Physiol*, 80 15-16P
- FISCHL, E, and R H KAHN 1928 Untersuchungen an einem Nerv Muskelpräparate zur Beobachtung einzelner quergestreifter Muskelfasern *Pfluger s Arch*, 219 33-46
- GELFAN, S 1930 Studies on single muscle fibers I The all-or-none principle *Am Journ Physiol*, 93 1-8
- GELFAN, S, and G H BISHOP 1932 Action potentials from single muscle fibers *Ibid*, 101 678-685
- 1933 Conducted contractures without action potentials in single muscle fibers *Ibid*, 103 237-243
- GRUNDFEST, H 1932 Excitability of the single fibre nerve muscle complex *Jour Physiol*, 76 95-115

- KATO, G. 1924. Theory of Decrementless Conduction in Narcotised Region of Nerve. *Tokyo*.
- LAPICQUE, L. 1926. L'Excitabilité en Fonction du Temps. *Paris*.
- LAPICQUE, L., and I. MEYERSON. 1912. Recherches sur l'excitabilité du pneumogastrique, première approximation de la chronaxie des fibres d'arrêt du cœur. *Mém. Soc. Biol.*, 72: 63-66.
- LOWE, O. 1922. Über humorale Übertragbarkeit der Herznervenwirkung. *Pflüger's Arch.*, 193: 201-213.
- LUCAS, K. 1909. The all-or-none contraction of the amphibian skeletal muscle fibre. *Jour. Physiol.*, 38: 113-133.
- . 1917a. The Conduction of the Nervous Impulse. *London*.
- . 1917b. On summation of propagated disturbances in the claw of *Astacus*, and on the double neuromuscular system of the adductor. *Journ. Physiol.*, 51: 1-35.
- PRATT, F. H., and J. P. EISENBERGER. 1919. The quantal phenomena in muscle: methods, with further evidence of the all-or-none principle for the skeletal fibre. *Am. Journ. Physiol.*, 49: 1-54.
- RITCHIE, A. D. 1932. The all-or-none principle. *Biol. Rev.*, 7: 336-349.
- ROSENBLUTH, A. 1932a. The mode of action of adrenin. *Am. Journ. Physiol.*, 101: 149-165.
- . 1932b. The chemical mediation of autonomic nervous impulses as evidenced by summation of responses. *Ibid.*, 102: 12-38.
- ROSENBLUTH, A., and W. B. CANNON. 1934. Direct electrical stimulation of denervated autonomic effectors. *Ibid.*, 108: 384-386.
- ROSENBLUTH, A., A. FORBES and E. F. LAMBERT. 1933. Electrical responses in the submaxillary gland. *Ibid.*, 105: 508-517.
- ROSENBLUTH, A., C. LEESE and E. F. LAMBERT. 1933. Electrical potentials in smooth muscle. *Ibid.*, 103: 659-680.
- ROSENBLUTH, A., and D. McK. RIOCH. 1933. Temporal and spatial summation in autonomic systems. *Ibid.*, 106: 365-380.
- RUSHTON, W. A. H. 1933. Lapicque's theory of curarization. *Journ. Physiol.*, 77: 337-364.





NEW BIOLOGICAL BOOKS

The aim of this department is to give the reader brief indications of the character, the content, and the value of new books in the various fields of Biology. In addition there will frequently appear one longer critical review of a book of special significance. Authors and publishers of biological books should bear in mind that THE QUARTERLY REVIEW OF BIOLOGY can notice in this department only such books as come to the office of the editor. The absence of a book, therefore, from the following and subsequent lists only means that we have not received it. All material for notice in this department should be addressed to Dr. Raymond Pearl, Editor of THE QUARTERLY REVIEW OF BIOLOGY, 1901 East Madison Street, Baltimore, Maryland, U. S. A.

BRIEF NOTICES

EVOLUTION

THE PHYLOGENY OF *ZEA MAYS*.

By Paul Weatherwax. *American Midland Naturalist*, University of Notre Dame, Notre Dame, Ind. 50 cents. 9 x 5½; 71; 1935 (paper).

Weatherwax accomplishes two useful things in this booklet. He sets down the botanical facts that are definitely and certainly known about *Zea mays* and closely related plants, and he critically examines the various hypotheses that have been advanced to account for the origin of a species that has such obvious handicaps in the struggle for existence. No one is better qualified than he for both tasks. The morphological data are presented in words and in drawings in clear and concise fashion and his criticisms are both vigorous and fair. He is guarded in his own conclusions:

It seems to me much more in accord with our general ideas of evolution to picture the forerunner of maize as having separated much earlier from the same stock as the *Andropogonae* and having pursued its own course of evolution in complete isolation from teosinte, arriving ultimately at the combination of characteristics previously listed in our description of the hypothetical wild plant at the time of its adoption by the Indians.

There is a touch of melodrama in his supposition that only the timely discovery of maize by some prehistoric Central American farmer saved the species from extinction. Taken as a whole it is a provocative piece of writing, and it may stimulate someone to find the facts that make a final judgment possible. There is a bibliography but no index.

GENERATION OF THE UNIVERSE AND "DESIGN FOR LIVING."

By Percy A. Campbell. Percy A. Campbell, 16208 Nelaview Rd., East Cleveland, O. \$1.50. 7½ x 5½; 101; 1934.

A philosophical treatise on life, evolution and the cosmos. The fundamental thesis is stated in the dedication page, "This book is dedicated to that most fundamental of all relativity principles, Hegel's doctrine of the inseparable twinship of being and non-being." From time to time a little theoretical physics, Euclidean geometry, and latest theories on evolution are brought in. The book is readable.



BEFORE THE DAWN OF HISTORY.

By Charles R. Knight. Whittlesey House, McGraw-Hill Book Co., New York. \$2.50. 9 x 12; xiii + 119; 1935.

This is a handsome volume which should have great appeal for both the art-lover and the biologist. Mr. Knight's murals of prehistoric subjects are well known to many people and one feels a service has been rendered in assembling so many of them in book form. A brief annotation, scientific in character, supplements the illustrations.



THE SCIENTIFIC BASIS OF EVOLUTION. *Second Edition.*

By Thomas H. Morgan. W. W. Norton and Co., New York. \$3.50. 8½ x 5½; 306; 1935.

The first edition of this book was reviewed

in Volume 8, page 101. In the second edition Professor Morgan adds a chapter on "Recent contributions to the theory of evolution," in which he deals with the newer work on the theory of the gene, the inheritance of acquired characters and the origin of species. There is a bibliography of 23 pages and an index.



GENETICS

KREBS UND VERERBUNG.

By *Hans R. Schinz and Franz Buschke.*

Georg Thieme, Leipzig. 21 marks (paper); 23 marks (cloth). 10 x 6½; 280; 1935.

The authors present a critical review of much of the recent work on the influence of heredity on cancer in man and in experimental animals. Many workers in the field may not agree with some of their deductions, but nevertheless this book is, it seems to us, one of the best surveys yet available on this still unstabilized subject. Beginning with a brief presentation of the principles of genetics, the authors review the literature on the genetics of spontaneous tumors in laboratory animals, genetics of human tumors, transplanted tumors in animals, and cancers produced by chemical, parasitic or x-ray stimulation. They are careful not to assign to all cancers conclusions obtained for one. Three broad groups are given in which hereditary and environmental factors differ in degree and importance in their production: (1) those almost entirely dependent on genetic factors, as in retinal glioma; (2) those mainly dependent upon exciting stimuli, such as tar cancers; (3) those in which both genetic background and stimuli, very often physiologic, appear to be essential. Most human cancers are assigned to this third and most difficult group.

An extensive bibliography and author and subject indices are provided.



THE GENETICS OF GARDEN PLANTS.

By *M. B. Crane and W. J. C. Lawrence.*

The Macmillan Co., New York. \$3.00.

8½ x 5½; xvi + 236; 1934.

Mr. Crane and Mr. Lawrence of the John

Innes Horticultural Institution have written an excellent textbook for students of horticulture and practical plant breeders. The fundamental principles of cytology and genetics are clearly and succinctly stated. Three chapters 30-40 pages in length are devoted to summaries of recent contributions to the knowledge of cytology and genetics of flowering and ornamental plants, vegetable and salad plants, and fruits; fields in which the authors have done important work. The last third of the book is a discussion of bud-sports and variations, incompatibility, sterility, and the appearance of new forms. There is a glossary, a bibliography, and a good index.



BLOOD GROUPS AND BLOOD TRANSFUSION.

By *Alexander S. Wiener. Charles C.*

Thomas, Springfield, Ill. \$4.00. 10 x 6½; xiv + 220; 1935.

A synthesis of the more important facts regarding blood groups. The author outlines the principles of iso-agglutination, technique of blood-grouping and blood transfusion together with their clinical applications. In more detail he presents the theories regarding heredity of blood-groups and includes a summary of Mendelian principles and statistical methods. The racial differences observed and the medico-legal applications are also amply discussed. The book is written in very clear style with sufficient references and will be found useful as a compendium of the more recent discoveries.



PRÄKTIISCHE ÜBUNGEN ZUR VERERBUNGSLEHRE. Für Studierende, Ärzte und Lehrer. Zweite vermehrte und verbesserte Auflage. Erster Teil: Allgemeine Vererbungslehre.

By *Günther Just. Julius Springer, Berlin.*

6 marks (paper); 6.90 marks (cloth).

9½ x 6½; vi + 137; 1935.

This excellent outline of laboratory exercises for beginning students of genetics has been greatly enlarged and rewritten to bring it up to date. The problems in biometric analyses have been increased from six to ten, and those on Mendelian experiments from seven to fifteen, whereas the

section on human pedigrees has been omitted from this volume of the work. The bibliography has been extended to include recent work.



DIE GENEALOGISCHEN METHODEN ALS GRUNDLAGE DER MENSCHLICHEN ERB-, RASSE- UND KONSTITUTIONSFORSCHUNG.

By Max Kassbacher. Otto Gmelin, Munich. 1.80 marks (paper), 2.70 marks (cloth). 8½ x 5½; 51, 1934.

A short exposition of the methods of collecting and portraying genealogical material. Some material on the racial and biological factors influencing family traits is included. The brochure is adequately illustrated and equipped with a bibliography of four pages.



PRINCIPLES OF GENETICS AND EUGENICS. A Study of Heredity and Variation in Plants, Animals, and Man.

By Nathan Fasten. Ginn and Co., Boston. \$2.80. 8½ x 5½, viii + 407, 1935.

The Jukes and the Kallikaks still doing business at the old stand! The straight genetic chapters are quite well done for an elementary text



GENERAL BIOLOGY

THE PHILOSOPHY OF A BIOLOGIST.

By J. S. Haldane. Oxford University Press, New York. \$2.50. 7½ x 4½; xii + 155, 1935.

In this interesting book Professor Haldane gives a succinct summary of his philosophy as it has developed out of his work as a physiologist. This has convinced him that the purely physical interpretation of the universe, however serviceable practically, is inadequate to deal with the integration and coordination which the living world manifests. Moreover when we come to deal with the conscious activities which psychology takes for its province the concept of personality, with its perceptions, motives and actions inextricably interrelated, is essential to any under-

standing of the subject. But personality implies more than the individual personality.

Our interest extends into the interests of other personalities, and over a past and future beyond the apparent time limits of individual personality. It includes the striving after right or good conduct, which is far more than an expression of mere individual interest. It also includes the search after truth, which, even though the truth is only partial, has binding authority for all personalities also the perception and furtherance of beauty, which appeals to all, regardless of their individual interests. We find also that right truth, and beauty are essentially one. We cannot interpret these features in any other way than that all-embracing personality manifests itself in individual personality, and that in this all-embracing personality is summed up the reality of our experience.

Thus the author leads us by successive steps to a view of the real universe as "a universe of personality, and the manifestations of God."



THE NATURAL HISTORY OF THE HITCHIN REGION.

Edited by Reginald L. Hime. Contributors: E. F. D. Bloom, G. B. Howells, J. E. Little, Ray Palmer, A. H. Foster, F. W. Edwards, W. H. Lane. Hitchin and District Regional Survey Assoc., Hitchin, Hertfordshire. 7s. 6d. net. 9½ x 6½; 256 + 25 plates + 2 folding maps; 1934.

This volume is meant to be a naturalist's guidebook to the region lying within a radius of ten miles of Hitchin, a town about thirty miles north of London. A multitude of naturalists have studied this district, their publications have been numerous and so, for the most part, this volume is not so much a record of new work as it is a discussion of the most noteworthy natural features, an annotated list of local plants and animals, and a bibliography of works dealing with the natural history of the region.

E. F. D. Bloom contributes an excellent article on geology and very neatly indicates the dependence of plant life and of human activities on the physiography of the region. His maps are very helpful and there is an Ordnance Survey map of the Hitchin district in a pocket at the back of the book. He also has a short article on aromatic and medicinal herbs.

The annotated list of the animals of the district is largely the work of Ray Palmer and A. H. Foster, the former treating most of the invertebrates and the latter treating the vertebrates and the Lepidoptera. F. W. Edwards treats the Diptera. J. E. Little's article on botany lays rather more emphasis on local botanists than it does on local plants. W. H. Lane discusses the archeological finds made in the district, from Acheulean flints to relics of the Norman period.

The book is very well illustrated throughout and has an index and bibliographic citations. It is unfortunate that the names of the authorities were not appended to the Latin names of animals and plants.



BIOLOGY FOR EVERYMAN. *In two volumes.*
By J. Arthur Thomson. Edited by E. L. Holmyard. E. P. Dutton and Co., New York. \$5.00. 7½ x 5; xviii + 1561; 1935.

Thomson's introduction to biology will probably turn out to be the cleverest piece of popular scientific writing of the year. In formal outline it follows the usual arrangement of the standard textbooks, but he seems to have adopted the principle that so far as possible he would include no technical details to which he was not going to refer a second time. His emphasis is on the interrelationships between the several parts of an organism and on the interrelationships that exist between different species under natural conditions. Its chief merit, it seems to us, is that it makes it possible for a reader to get a synoptic view of nature that he might ordinarily lose in a confusion of details. It will not take the place, of course, of the standard textbooks, but it will teach some biology in a thoroughly sound manner to a multitude of people who might not learn it otherwise. The factual content of the two volumes is about the amount a college student would be introduced to in his first two or three biology courses but it is presented in an informal way and with a wealth of apposite anecdote that only an experienced teacher would have at his command. There is an excellent index but the illustrations are poor.

A MANUAL OF DRAWING FOR SCIENCE STUDENTS.

By Justus F. Mueller. Farrar and Rinehart, New York. \$1.75. 8 x 5½; xiii + 122; 1935.

Biologists will welcome the appearance of a textbook of drawing that is based on sound technical principles and is concisely and clearly written with their needs in mind.

The first five chapters of the book, and part of the sixth, discuss principles involved in even the most elementary problems of drawing, and hence should be of interest to the general student. The sixth and seventh chapters are designed to meet the needs of advanced students and research workers, who have greater facilities for making drawings, and who must produce work acceptable for publication.

Mueller wisely undertook to explain the reason for each of the general principles and procedures he recommends, an appeal to the prejudices of his readers, and supplemented his words by series of sketches showing the stages in the construction of a number of drawings. His methods, and the order in which he presents them, are based on orthodox art school practice. There are ninety well chosen illustrations and there is a good index.



COLD SPRING HARBOR SYMPOSIA ON QUANTITATIVE BIOLOGY. Volume II.

The Biological Laboratory, Cold Spring Harbor, Long Island, N. Y. \$3.35.
10½ x 7½; xii + 284; 1934.

These papers and edited discussions growing out of the second Cold Spring Harbor Symposium deal with the general question of "growth." The papers cover a wide variety of subjects under this general heading dealing with chemical, physical and mathematical aspects of growth; genetic and ontogenetic aspects of growth; growth as exemplified by experimental population studies on yeast, protozoa and *Tribolium*, and growth as influenced by radiation. The papers, quite naturally, form a rather heterogeneous collection of material in which there is little integration of the subject matter. However, many of the reports are certainly valuable and authoritative and the enterprise as a whole seems worthy of praise. The discussions after

each paper frequently bring out suggestive points and also add a personal touch to the volume which is quite novel.



URDEUTSCHLAND. *Deutschlands Naturschutzgebiete in Wort und Bild. Lieferungen 1, 2, 3, 4, 5, 6.*

By Walther Schoenichen. J. Neumann, Neudamm. 2 marks each. $10\frac{1}{2} \times 8\frac{1}{2}$; Lief. 1, 1-24 + 9 plates; Lief. 2, 25-48 + 9 plates; Lief. 3, 49-72 + 9 plates; Lief. 4, 73-96 + 9 plates; Lief. 5, 97-120 + 9 plates; Lief. 6, 121-144 + 9 plates; 1934-35 (paper).

This beautifully produced work will appear in two volumes of twelve *Lieferungen* each, to be published monthly over a space of two years. It may be said to be part of the Appreciation of Nature in the Vaterland movement, and is intended for persons interested in the conservation of wild life, foresters, school and public libraries, hikers and travel bureaus. The first volume will be confined to geology, the second to plant and animal life. There are abundant beautiful illustrations, each number containing a colored plate (usually a reproduction of an oil painting) and eight full-page photographs, besides smaller photographic reproductions, maps and schematic drawings in the text.



BIOLOGY FOR MEDICAL STUDENTS.

By C. C. Hentschel and W. R. Ivimey Cook. Longmans, Green and Co., New York. \$7.00. $8\frac{1}{2} \times 5\frac{1}{2}$; xii + 618; 1932.

This book is intended as a text for pre-medical students. It contains examples from zoology and botany needed to illustrate fundamental principles. Since the future of the student is constantly kept in mind such matters as pathogenic protozoa and the physiology of endocrine glands in relation to health and disease are mentioned. A whole chapter is devoted to the tape worm (*Taenia*). The book is well written, and has all of the necessary elements needed for a good biological foundation.

APERÇUS TOUCHANT LES OISEAUX, LES INSECTES ET LES PLANTES. (*Trois Mondes d'une Vie Intense Autour de Nous*).

By A. Guéniot. J.-B. Baillière et Fils, Paris. 20 francs. $7\frac{1}{2} \times 4\frac{1}{2}$; iii + 224; 1934 (paper).

These three little essays on birds, insects and plants were written after Doctor Guéniot passed his eighty-fifth birthday (he is now 102) and after he had retired from medical practice. One of his motives in writing them was to prove that old age does not necessarily mean an ignominious and idle retirement. The essays take the form of field notes on such animals and plants as he kept under observation and are intended, as he says, for children and old people. There are no illustrations and there is no index.



BIOLOGY.

By Frederick L. Fitzpatrick and Ralph E. Horton. Houghton Mifflin Co., Boston.

\$1.76. $7\frac{1}{2} \times 5\frac{1}{2}$; xiv + 611 + xlv; 1935.

A high school text in biology is here presented, designed to teach understanding of the basic principles of the living world. It is put together and written in an interesting and straight-forward manner without the interjection of the absurd and artificial devices to amuse and stimulate interest that have unfortunately characterized some of the recent biology texts. It appeals to one as a scientific book simplified and condensed to fit the capabilities of high school pupils.



BIOLOGICAL MOVIE BOOKLETS. Vol. I, Normal Cell Division. Vol. II, Maturation of Sperm. Vol. VI, Fertilization.

By Clyde E. Keeler. American Genetic Association, Washington. Set \$1.50 (Separately: Vol. I, 50 cents; Vol. II, 60 cents; Vol. VI, 70 cents.) $1\frac{1}{2} \times 2\frac{1}{2}$; pages unnumbered; 1935.

These movies are amusing and instructive, though it is unfortunate that *Ascaris* is chosen to illustrate normal cell division, since the behavior in all parts is not always typical. There is a brief introduction to each booklet, explaining the contents, but

without textbook preparation the student will not learn a great deal.



LA FÉCONDATION chez les Animaux et chez les Végétaux.

By Henri Coupin. J.-B. Baillière et Fils, Paris. 22 francs. 8½ x 5½; 203; 1934 (paper).

A very good discussion of the phenomenon of fertilization in the plant and animal kingdoms. The book is liberally illustrated and has an index. It is one of the *Actualités Scientifiques et Industrielles* series.



HUMAN BIOLOGY

THE RESTRICTIVE LAW OF POPULATION. Imperial College of Science and Technology, Huxley Memorial Lecture, 1934.

By Johan Hjord. The Macmillan Co., New York. 50 cents. 8½ x 5½; 46; 1934 (paper).

Professor Hjord's analysis of the population problem grounds itself fundamentally upon two propositions: (1) that the logistic curve (which he calls the "sigmoid curve") accurately and very generally describes the growth of populations of living organisms, and (2) that Newton's law of motion applies to biological phenomena when stated in the following form:

"Any given historical equilibrium will remain as such or in an incipient state of change, unless the action of forces in this environment alters this condition of things."

His discussion of the world's present difficulties is sound and shrewd:

This comprehension of the structure of society and of the many and various forms of occupation, all at different stages on the curve of growth, furnishes, perhaps, the clearest picture of the social mentality and of the social organization which has created our European civilization. Europe is an edifice founded and built up on the intelligence of millions of people—on their work and the ingenious use they have made of a thousand possibilities. The multifarious little undertakings created in this way occupy, at any given time, very different stages in the evolution of human occupations. This in itself makes it impossible for them all to offer their employees the same equal conditions of life at the same time.

As a growing population approaches its maximum

height and further extension of the environment seems to be excluded, the whole foundation of society seems to become more unstable, so that a process of inner dissolution (struggle for existence) sets in, which often causes the foundation to collapse in sudden ruin.

The divided state, the struggle for existence, war, are symptoms of over-population; they are not remedies for over-population. The object of society is, if possible, to prevent over-population from occurring. If over-population exists, the proper remedy is to limit the divided state. These words enshrine the social philosophy of biology. War destroys the wealth, the organizations, the liberty in the environment of populations, and therefore creates over-population in relation to the reduced environment. War creates an aftermath of experiments intended to mitigate the suffering which is part of the disease created by war; and these remedies often prove worse than the disease itself because they generally prevent the national and international division of labour and nevertheless are considered and applied as a means of creating new wealth for the nation. In reality the purpose of these means is to maintain a maximum population in the reduced environment, and experience always shows that this can only be done by lowering the general standard of life.

All serious students of population will do well to read and ponder over this pamphlet by a distinguished biologist.



THE ESSENTIAL FACTORS OF SOCIAL EVOLUTION.

By Thomas N. Carver. Harvard University Press, Cambridge. \$5.00. 8½ x 5½; xi + 564; 1935.

This volume by a distinguished economist represents, according to his own statement, a life-long interest that he had hoped would ultimately jell into a "monumental work on the general subject of Social Evolution." In the end, however, he concluded that this contemplated treatise was beyond his powers, and so produced the present volume, which he regards as a compromise between his "ambition and his ability."

The result is an interesting, useful, and, particularly to the biologist, a refreshing work. For Prof. Carver's viewpoint and approach throughout is much more intelligently biological than most sociologists seem able to achieve, or even to understand. He stresses survival value as a major element in the evolutionary process, and interprets social evolution in terms of variation and selection. These phenomena as observed in human social groups

are regarded as in direct continuation of the corresponding phenomena among individuals in biological evolution, with the result that in the production of human societal relationships variation and selection among social groups are additional factors added to the strictly biological elements in the picture. The relationship of this point of view to that of emergent evolution, as developed particularly by Wheeler, is evident.

The book is abundantly documented, readably presented, and well indexed. The best thing about it is its good sense. We have space for illustrations of the point only by one quotation. Discussing the ancient problem of environment and heredity Professor Carver says (p. 403):

One of the great facts of human ecology is that men mold their environment almost as much as the environment molds them. Nor is the molding of the environment confined to the physical side. Men create for themselves a social environment which is quite as artificial or man-made as the new physical environment which they build around themselves. One weakness no environmentalist has yet overcome. No one is able to say what a good environment is like, because no environment is good for everybody. Biologists have found out a few things about heredity, sociologists have found out very little, if anything, about the way any given environment affects character. That which is a good environment for one person is a bad environment for another. The impressions one individual receives from a given set of circumstances are different from those which another person receives.

Altogether we strongly recommend this book to students of human biology.



AN INTRODUCTION TO CULTURAL ANTHROPOLOGY.

By Robert H. Lowie. Farrar and Rinehart, New York. \$3.50. 8½ x 5½, xiii + 365; 1934.

Professor Lowie's experience as a teacher has shown him "that most students of cultural anthropology and other social sciences are very slow in acquiring an elementary knowledge of culture history, and that many fail to acquire the relevant facts and concepts even years after they have launched on a professional career as anthropologists." To remedy this deficiency is the object of this excellent book, which is arranged under the following chapter headings: Introduction: cul-

ture, race and progress; hunting, fishing, gathering; farming; domestic animals; fire, cooking and meals; dress and ornament; houses and settlements; handicrafts; trade and transportation; amusements; art; war; marriage and the family; the clan; rank, etiquette and property; government and law; religion and magic; knowledge and science. In dealing with these topics the objective has been "to stress the simplest tribes, such as the Fuegians and Australians, and, on the other hand, to link the culture of illiterate peoples with the higher civilizations, past and present."

Although this is not a polemic, like Radin's *The Racial Myth*, against attempts to explain culture in terms of race, the racialists will get very little nourishment out of it. "Since biological change occurs slowly and cultural changes occur in every generation, it is futile to try to explain the fleeting phenomena of culture by a racial constant. We can often explain them—in terms of contact with other peoples, of individual genius, of geography—but not by racial differences."

A bibliography of 13 pages, an index and maps showing the location of the cultures discussed are provided.



LEXICAL EVIDENCE FROM FOLK EPIGRAPHY IN WESTERN NORTH AMERICA: a Glossarial Study of the Low Element in the English Vocabulary.

By Allen W. Read. Paris (Privately printed). 9 x 5½, 83; 1935.

Anthropologists, psychologists and students of human biology generally will find in this small volume a record, of permanent historical value, of the current American fashions in obscene inscriptions. It is quite evidently an extremely ancient urge that leads human beings to adorn with obscene drawings and written sentiments the places set apart for the reception of digestive and excretory waste products. The author of this treatise, a distinguished philologist and Research Associate in English in the University of Chicago, has brought together a substantial and probably fairly complete (particularly for the Middle and Far West) collection of such inscriptions, and discussed them thoroughly and learnedly from the viewpoint

of comparative linguistics, history and ethnology. The results are of great interest to the student of folkways. One of the strangest of these results, all things considered, is the extraordinarily slight change there has been in the sentiments expressed and in the form of their expression since this type of folk epigraphy began, which probably means when writing began. Mr. Read quotes a number of examples from the *Corpus Inscriptionum Latinarum* for comparison with those of the present day, and then goes on to say (p. 22): "So close is the parallelism both in spirit and in form between these Latin epigraphs and the ones found in western North America that clearly the Americans are merely carrying on the classical tradition."

Obviously this book cannot be freely distributed under our laws. Its circulation is restricted to "students of linguistics, folk-lore, abnormal psychology, and allied branches of the social sciences," and only a very limited edition has been printed.



SPIDER WOMAN. *A Story of Navajo Weavers and Chanters.*

By Gladys A. Reichard. The Macmillan Co., New York. \$3.50. 8½ x 5½; xii + 287 + 9 plates; 1934.

The author, a young professor at Barnard College, spent several summers among the Navajo, the outstanding weavers of the Western hemisphere, endeavoring to master the complicated art of weaving. The book is written in a pleasant narrative style, and while largely concerned with her own struggles with carding and spinning, handling looms, wools, batters and combs, through it all runs a story of Indian weavers and chanters, Indian character and customs. Among the latter of particular interest are the chants and sand paintings, of which the author says:

The chants which I think of as charms include singing, administration of herbal medicine, and application of sacred objects to the body. Among the most sacred are the sand-paintings, made at particular times during the chant, by artists allowing colored sand to sift through their fingers in the most incredible and regular manner. The result is an astonishing composition of symbolical figures in the softest shades of black, blue, yellow, white, red and pink on a pale tan background. The artists themselves need skill,

but they need not know the pictures. This is the duty of the chanter who directs them. The art, a beautiful and unusual one, is evanescent. Paintings which take hours to make are, by the rules of the chant, ruined in twenty minutes, removed in less than half an hour after their completion. For these reasons there is considerable interest on the part of whites to preserve this transitory art [by executing the paintings on paper with tempera, and weaving the designs into blankets].

The book is rather too sketchy to be much of a contribution to ethnology or to the subject of historic fabrics. It is well illustrated with very good photographs.



THE ROCK-ENGRAVINGS OF GRIQUALAND WEST AND BECHUANALAND, SOUTH AFRICA.

By M. Wilman. Alexander McGregor Memorial Museum, Kimberley; Deighton Bell and Co., Cambridge. 25 shillings net. 12½ x 9½; xii + 78 + 70 plates and folding map; 1933.

This beautifully printed quarto by Miss Wilman, who is Keeper of the Kimberley Museum, records the results of an extensive, though not complete, survey of the strange rock engravings of South Africa. A high standard of scholarship is maintained throughout the report, which opens with a bibliographic section in which the prior literature on these engravings is critically reviewed and digested.

The engravings are of animals, men, plants, geometrical designs, and footprints of men and animals of various sorts. They are made either as incised lines on the surface of the stone, or as stippled ("pecked") outlines. No one knows with what tools they were made—Miss Wilman thinks probably a diamond, others think quartz or chalcedony flakes. They are probably older than any but the oldest of the rock paintings in the same region. Miss Wilman attempts to specify their age no more precisely than "many centuries" for the oldest engravings. Artistically many of them are charming, and indicate a high talent.

The report is copiously and intelligently illustrated with some 70 photogravure plates, 16 text figures and a detail map showing the location of the sites. There is a bibliography of seven double-column pages, and an adequate index.

While this cannot be regarded as an

epoch-making contribution to ethnology, it is a sound, careful, thorough objective record of fast disappearing artefacts of a primitive civilization and as such of great value. The Royal Society of South Africa and the Carnegie Corporation of New York made no mistake in financially aiding this work.



THE POPULATION PROBLEM IN INDIA. A Census Study.

By P. K. Wattal. Bennett, Coleman and Co., Bombay. Rs. 3-8. 7½ x 5; xii + 185; 1934.

Brief and unpretentious as it is, this book is one of the most important treatises on population questions in recent years, in our considered opinion. It is an enlarged and completely rewritten edition of a work that first appeared in 1916. The author is a competent statistician, fellow of both Royal Statistical and the Royal Economics Societies. He evidently knows his India thoroughly.

With admirable terseness, absence of sentimentality and moral judgments, Mr. Wattal exposes realistically the actual population situation in India, documenting the position at every step from official census figures. On the basis of his analysis of the actualities, which in sum are pretty shocking, he proceeds to suggest sensible steps that might be taken for their amelioration. These include reduction of the death-rate by more effective public health measures; reduction of the birth rate through birth control; a strenuous campaign for widow re-marriage; extension of the Sarda Act (against infant and child marriages); eugenic marriage restrictions.

Writers of the western world on population love to talk about India, mostly without taking pains to inform themselves as to the realities. We cannot too strongly recommend this little book as a healthy corrective to a good deal of misinformation and nonsense now current. It is a fine piece of work.



FIFTY YEARS OF MEDICINE AND SURGERY. An Autobiographical Sketch. With special

reference to the organization and administration of Surgery, Gynecology and Obstetrics, the Clinical Congress, the American College of Surgeons, the Gorgas Memorial Institute, and the participation of the medical profession in the World War. Based on personal diary, professional writings, and digest of professional activities during fifty years. Prepared in narrative form for the lay public and the medical profession.

By Franklin H. Martin. Surgical Publishing Co., Chicago. Privately published; not offered for sale. 8½ x 5½; xxvii + 449 + 21 plates; 1934.

This is an interesting chronicle of a man who started practicing medicine in 1880 before Sir Joseph Lister revolutionized surgery with his idea of antiseptics. The author was among the first of American surgeons to put Lister's theories into actual practice in the operating room. In the years he practiced he contributed much to modern medicine and surgery. It was he who conceived and developed the journal *Surgery, Obstetrics and Gynecology*. He also organized the American College of Surgeons.

Doctor Martin, in the course of his long life as a practitioner, teacher and experimentalist, met many of the outstanding physicians and surgeons of this and other countries; some of his contacts with these people are related in his book. This volume will be enjoyed by the admirers and friends of F. H. Martin.



HANDEDNESS, Right and Left.

By Ira S. Wile. Lothrop, Lee and Shepard Co., Boston. \$2.75. 8½ x 5½; xiii + 439; 1934.

A comprehensive survey of a subject which is now recognized as an important field by psychologists and students of behavior. The author has delved extensively into the history of the use of the right and left hands. Indeed he carries his studies back to hand preferences in primitive man and even includes a section on heliotropism and heliocentrism. Other subjects which are discussed are philology and hands, causation of dominant handedness, magic and hand values and religion and hand symbolism. In the final section the

author urges that natural handedness should be fostered and conserved. "Handedness as a biological function is one means of releasing the energy of the total personality. The social regulation of handedness reduces energy efficiency. The whole being is most harmonious when its basic unity is respected in terms of structure and function" and "The conversion from right-handedness to left-handedness is not common, but it is, none the less, fraught with distinct hazards. The conversion from left-handedness to right-handedness is too commonly practiced and it frequently involves very definite difficulties which are expressed in the forms of seemingly trifling, but frequently severe, disorders of behavior. Society often pays a high price for its folly."

The volume contains a lengthy literature list and an author and subject index.



HELL-HOLE OF CREATION. *The Exploration of Abyssinian Danakil.*

By L. M. Nesbitt. Alfred A. Knopf, New York. \$3.75. 8½ x 5½; xi + 380 + viii + 16 plates and folding map; 1935.

The story goes that three times expeditions were launched to explore the Danakil territory which lies along the Red Sea in Eritrea. Each of the expeditions met with disaster and none of the European members ever lived to tell the tale. The fourth expedition "got through" as is reported in much detail in the present book by author Nesbitt. Accounts are given of the vicissitudes of the journey itself; word pictures of native faunas and floras, and notes on the mores and folkways of the native inhabitants.

On the whole the book is interesting and it undoubtedly adds many data of general anthropological interest to our knowledge of Africa. Photographs scattered throughout the pages are appealing and increase the value of the work. The reviewer felt that the book was too long and set forth some events which could have been profitably condensed—an opinion which may not be shared by other readers.

L'INDIVIDUALITÉ.

Exposés by Maurice Caullery, C. Bouglé, Pierre Janet, J. Piaget, Lucien Febvre. Félix Alcan, Paris. 15 francs. 8 x 6; iii + 157; 1933.

The *Semaine Internationale de Synthèse* is an annual course of lectures and discussions in which some topic is treated from the viewpoint of various sciences. In the study of the origins of society which was treated in 1930 it became evident that this in turn involved the problem of the relation between society and the individual. In order to be sufficiently *gründlich*, this treatment of individuality begins with a lecture on the principal aspects of individuality in organisms, by Maurice Caullery. In biology, he points out, the word "individuality" is used in two senses: that of unity and that of uniqueness. The former consists in a concentration of elements, a synthesis, the latter results from the diversity of the concentrated elements. Janet treats individuality in psychology; Bouglé, Piaget and Febvre individuality and history, while from a discussion on the individual and society the conclusion emerged that "individuality is that effort of synthesis by which the diverse becomes unified and organized, by which being tends to the greatest possible existence, by which it strives to realize the maximum of being, to employ a favorite expression of Leibniz."



THE CRIPPLED AND THE DISABLED. *Rehabilitation of the Physically Handicapped in the United States.*

By Henry H. Kessler. Columbia University Press, New York. \$4.00. 9 x 6; xiii + 337; 1935.

This excellent survey of the needs of the disabled and the extent to which these needs are met by practice and intent is a useful handbook for social workers and legislators. As a group of vocationally maladjusted persons, the disabled are divided for convenience into the child cripple, the industrially disabled, the military disabled, the chronically disabled, the blind, deaf and dumb. Specific and general legislation in the different states is reviewed. For comparative purposes,

some foreign legislation is included. In chapter 23 the author summarizes his findings and gives his conclusions. He believes "that potentially all the needs of the crippled and disabled can be met without resort to evolutionary changes in our social philosophy." In a series of appendixes are given (a) Compensation provisions for second major injuries in those states not having second-injury funds, (b) Summary of vocational rehabilitation legislation by states, and (c) legislation for the blind. The volume concludes with an extensive bibliography and a list of official and semi-official publications and an index.



ROBERTY. *Le Positivisme Russe et la Fondation de la Sociologie.*

By René Verrier. Félix Alcan, Paris. 18 francs. 9 x 5½; 233 + 7 plates; 1934 (paper).

A short biography of Eugene de Roberty, which gives in chronological order the evolution of his ideas. This Russian sociologist belongs to that group of students of social phenomena who discuss ideas but seldom investigate facts. A disciple of Comte and Littré, his sociological writings reveal the common preoccupation of most of his contemporaries as to whether sociology is a "major" or "minor" science, the difference between unknown and unknowable, etc. The nucleus of Roberty's ideas is that the biological being is the result of a long process of adaptation to the environment. The conscience of this bio-individual is derived from a first psychophysical interaction and is the realization of sociality. The conscience of the collectivity arises from a superimposition of individual consciences, their similarities reinforced, their differences eliminated.

The author of this biography is very sympathetic to this philosophy and regards Roberty as one of the great founders of sociology.



EDUCATION OF THE FOUNDING FATHERS OF THE REPUBLIC. *Scholasticism in the Colonial*

Colleges. A Neglected Chapter in the History of American Education.

By James J. Walsh. Fordham University Press, New York. \$3.50. 9½ x 6½; xii + 377; 1935.

Doctor Walsh has shown definitely that Scholasticism continued to be the mode of teaching in certain of the American colleges until the nineteenth century. He does this by following the broadsheets issued at commencement time showing the subject to be defended by the candidates for degrees. The subject matter and in some cases even the wording of these theses had a decided Scholastic flavor from the first commencement of Harvard through 1810. The first chapter gives an interesting general account of education in the early days of the American colleges. The next seven chapters discuss in more detail the situation of the first seven colleges established, especially as regards the commencement theses.

This is a very valuable book for people interested in the history of education and also for the student of the colonial period.



MEDICAL TACTICS AND LOGISTICS.

By Gustavus M. Blech and Charles Lynch. Charles C. Thomas, Springfield, Ill. \$4.00.

9 x 6; xiv + 205 + 4 folding maps; 1934. Colonels Blech and Lynch are convinced that the next war in which this country engages will be a war of maneuver quite unlike the World War. Their book is mainly an exposition of the classical principles of war presented in simple language and elaborately illustrated by examples with the object of instructing medical men how to adapt their activities to the needs of rapidly moving bodies of troops. About a hundred pages are devoted to detailed description and critical analysis of an imaginary campaign between two armies maneuvering near Gettysburg, Pennsylvania. Excellent topographical maps of the region are provided. If any of our readers are curious to know how hypothetical wounded men are treated in a sham battle this book will enlighten them. The organization of the medical service is summarized and the functions of various officers are defined. There is a glossary, bibliography, and an index.

LIVING WITH THE WEATHER.

By *Clarence A. Mills*. *Clarence A. Mills*,
University of Cincinnati. \$1.50. 7 $\frac{3}{4}$ x 4 $\frac{1}{2}$;
viii + 206; 1934.

Doctor Mills discusses the effects of weather and climate on man. He states that wide variations within an optimal range result in greater energy. He follows Huntington, but goes much further in that he attributes business cycles and our crime wave to the extreme variability of the North American climate. This, he claims, is also responsible for the high tension of our life and therefore indirectly for our immoderate use of stimulants. He advocates greater use of air conditioning to offset the debilitating effect of the moist heat of the tropics.

There are many interesting and valuable suggestions in this book, but it is our opinion that the author has permitted himself to be carried away by his enthusiasm to a certain extent.



KRANKHEIT UND TOD IM SCHICKSAL BEDEUTENDER MENSCHEN.

By *Adolf Braun*. *Ferdinand Enke, Stuttgart*. 3.60 marks (paper); 4.80 marks (cloth). 9 x 6; iii + 104; 1934.

Introduced by a short section on the influence of physical constitution on the choice of and capacity for work and outlook on life of various types of geniuses, this is a list, with some biographical matter, of great men in various fields and the causes of their death. In some cases the causes, or at least contributing factors, here given are not those popularly known. The causes in the order given in the book are: old age; apoplexy; violent deaths; cancer; tuberculosis; syphilis; mental diseases; drunkenness and criminality; chronic diseases; acute diseases. There is an index of names and diseases.



VOLLBLUTNEGER UND HALBZWERGE. Forschungen unter Waldnegern und Halbpygmäen am Ituri in Belgisch-Kongo.

By *Paul Schebesta*. *Anton Pustet, Salzburg*. 8.50 marks (paper); 9.80 marks (cloth). 9 x 6; 271 + 48 plates; 1934. An interesting account of two years'

travel in those parts of equatorial Belgian Congo inhabited by the pygmies. The material in this book is confined, however, more to the Bantu tribes among whom the pygmies live in a more or less biocenotic relationship, the pygmies having been treated more thoroughly by the author in another book, *Bambuti*. The physical characteristics, customs, beliefs and history as far as it is known, of the various tribes are described separately and in detail. In only two cases here discussed, namely the Batwa in Ruanda and the Bachwa, has intermarriage between the Bantus and the pygmies, presumably at some remote time in the past, given rise to races of half-dwarfs. The book is abundantly illustrated with excellent photographs and an index is provided.



THE SOUTH AFRICANS. New Edition, rewritten and greatly enlarged.

By *Sarah G. Millin*. *Constable and Co., London*. 7s.6d. net. 7 $\frac{1}{2}$ x 5; x + 332; 1934.

This book first appeared in 1926 and was later reprinted several times. So rapidly, however, has South Africa changed politically, economically and racially within the last eight years that Mrs. Millin has entirely recast and enlarged her interesting volume. She deals with

the racial position of English, Jews, and Asiatics in South Africa; with the Union's new Status Act and the struggle over its adherence to the British Empire; with the rise of the Dutch to power and their relations with the British; with the effects of Nazi propaganda on various elements of the population; with the strange preliminaries of the Smuts-Hertzog Coalition; with the abandonment by South Africa of the Gold Standard, with the results of enquiries in the Poor White and Native questions.

The volume is well indexed.

MEXICO EN CIFRAS (*Atlas Estadístico*) 1934.

Secretaria de la Economía Nacional; Dirección General de Estadística, Mexico, D. F. 12 $\frac{1}{2}$ x 17 $\frac{1}{2}$; 180; 1934.

This statistical atlas of Mexico is extremely well done in respect of both planning and execution. The Director General of Statistics, Ramon Beteta, under

whose direction it was prepared, merits great praise for so fine an accomplishment. The work is divided into ten sections dealing successively with: Geophysics, population, education, agriculture, industries, minimum wages, communication and transport, foreign commerce, money and banking, and public finance. Each right hand page is filled by a graph or map (or series of such) while the facing left-hand page carries the explanatory text. The graphs are executed with much artistic skill. Altogether this is an excellent reference source.



THE VICOMTE IN THE KITCHENETTE. *Being the Art of Cooking within restricted space, limited time and reduced income; with the manner how to make easy, dainty, and tasty Dishes; all kinds of inexpensive and rapidly made Novelties; together with a Glossary of Cooking Terms; with finally much advice to those about to set up small house.*

By *Vicomte de Mauduit*. Stanley Nott, London. 3s. 6d. $7\frac{1}{2} \times 4\frac{3}{4}$; 146; 1934.

The Vicomte writes smartly about cooking, this time in the limited environment of the ultra-modern apartment, where what does duty for kitchen is not big enough even to feed a cat in and do anything else at the same time, let alone swing it. Mary Shepard's drawings that illustrate the book are even smarter than Mauduit's writings.

There are some good recipes in this little volume, along with a somewhat too heavy seasoning of trite banalities. We form the impression that, apart from the occasional novel and really seductive recipe, it will be found really useful only by the callowest newly-wed who does not know how successfully to boil a potato.



ALASKA NATIVES. *A Survey of Their Sociological and Educational Status.*

By *H. Dewey Anderson and Walter C. Eels*. Made under the Auspices of The School of Education of Stanford University at the Request of the United States Office of Education. Stanford University Press, Stanford University, Calif. \$5.00. $10\frac{3}{4} \times 8$; xvi + 472 + folding map; 1935.

This investigation, financed by a grant from the Carnegie Corporation, was made at the request of the United States Office of Education and was supervised by the School of Education of Stanford University. It is divided into two parts. The first deals with the ethnology of the native Alaskans and their present social structure, the second with their education. The survey is by far the most comprehensive that has ever been made on these people and is an important book for all who are interested in them. The volume is extensively illustrated and documented, data are arranged in 177 tables and 100 figures, additional material is contained in a group of appendices and there is a detailed index.



THE CHINESE MEDICAL JOURNAL, Vol. 48, No. 12. Davidson Black Memorial Anatomy and Anthropology Number.

Published by the Chinese Medical Association. Peiping Union Medical College, Peiping. Mex. \$1.50, G \$0.60, or 2s. 6d. 10×7 ; 158; 1934 (paper).

Three Forewords open this memorial in honor of a great anthropologist, whose early death was the greatest loss which that science has suffered in a generation. The first Foreword is a brief introductory statement by Dr. Fortuyn. Then follows a bibliography of Black's writings, in turn followed by a reprint of the introductory paragraphs of Dr. Black's Croonian Lecture giving the history of the discovery of the Choukoutien site of *Sinanthropus pekinensis*. The remainder of the number is devoted to eleven papers on anatomical and anthropological subjects contributed by old colleagues and students. The inspiration of Black's leadership is evident in each one of them.



MAHAN-JO-DARO. *One of the Most Ancient Sites of the East which has Aroused World-Wide Interest.*

By *Bherumal Mahirchand*. Bherumal Mahirchand, D. J. Sind College, Karachi, Bombay, India. Rs. 1.4. $7\frac{1}{8} \times 4\frac{1}{2}$; iv + 93; 1933.

Until a few years ago little was known of the pre-Aryan culture of India. How-

ever, the excavations at Mahan-jo-Daro and Harappa have shown that, in the words of Sir John Marshall, "five thousand years ago, before ever the Aryans were heard of, the Panjab and Sind, if no other parts of India as well, were enjoying an advanced and singularly uniform civilization of their own, closely akin but in some respects even superior to that of contemporary Mesopotamia and Egypt." Mr. Mahirchand bases his book not only on Marshall's authoritative account of his excavations, *Mohenjo-daro and the Indus Civilization*, but on articles of varying reliability published in newspapers and magazines.



GUIDING YOUR CHILD THROUGH THE FORMATIVE YEARS. *From Birth to the Age of Five.*

By *Winifred de Kok*. *Emerson Books*, New York. \$2.00. $7\frac{1}{4} \times 4\frac{7}{8$; 191; 1935.

A practical handbook for mothers and fathers on the psychology of the young child. Information is simply given about such matters as play, tantrums, fears and fancies, sex education, etc. The point of view of the child is admirably stressed in discussing his problems. A useful book for young parents.



BIOLOGICAL POLITICS. *An Aid to Clear Thinking.*

By *F. William Inman*. *William Wood and Co.*, Baltimore; *John Wright and Sons*, Bristol. \$3.00 (U. S. A.); 7s. 6d. net (Great Britain). $7\frac{1}{4} \times 4\frac{3}{4}$; xi + 258; 1935.

The author, a eugenicist of the more radical type and an outspoken believer in Nordic superiority, gives his opinions on various and sundry aspects of heredity and its relation to social evolution. There is very little originality but the book makes amusing reading.



IDEALE KÖRPERFORM UND ERNÄHRUNG. *Zugleich eine Anleitung zu zweckmässiger Ernährung.*

By *Carl E. Hartmann*. *Otto Gmelin*,

Munich. 2.70 marks (paper); 3.75 marks (cloth). $9\frac{1}{4} \times 6\frac{3}{8}$; 111; 1934.

After a brief introduction on human constitutional types, the author discusses the influence of exercise and various foods in the attainment of an ideal figure. A table of the calory values of foods and drinks, and an index are included. The book belongs to the *Arzt als Erzieher* series.



HOW SAFE IS HOME?

By *Howard W. Green*. *Cleveland Health Council*, Cleveland, O. 50 cents. $10\frac{1}{4} \times 8\frac{3}{8}$; iii + 48; 1934 (paper).

This is a statistical study of accidents in Cleveland homes from January 1929 to July 1934. All types of accidents are classified according to age, sex, economic status, and geographic distribution in the city. Falls and burns were the two most frequent. There are numerous maps, graphs, and tables.



BULLETIN DER SCHWEIZERISCHEN GESELLSCHAFT FÜR ANTHROPOLOGIE UND ETHNOLOGIE 1934-35. *11. Jahrgang.*

Société Suisse d'Anthropologie et d'Ethnologie, *Institut Anthropologique de l'Université*, Zurich. 2 francs. $9 \times 6\frac{1}{4}$; 35; 1934-35 (paper).

JUVENILE-COURT STATISTICS AND FEDERAL JUVENILE OFFENDERS, 1932. *Based on Information Supplied by 267 Juvenile Courts and by the United States Department of Justice. Sixth Annual Report.* Bureau Publication No. 226.

By *U. S. Department of Labor*, *Children's Bureau*. *U. S. Government Printing Office*, Washington. 10 cents. $9\frac{1}{4} \times 5\frac{7}{8}$; iii + 129; 1935 (paper).



ZOÖLOGY

A STUDY OF THE LIFE HISTORY AND FOOD HABITS OF MULE DEER IN CALIFORNIA. *A Contribution from the Wildlife Division, United States National Park Service.*

By *Joseph S. Dixon*. *Wildlife Division, United States National Park Service*, 328

Hilgard Hall, Berkeley, Calif. 25 cents.
9 x 6; 146; 1934 (paper).

This is an important, complete, and interesting compilation of field observations on the life history and feeding habits of *Cervus hemionus* (= *C. macrotis*) which is found in northeastern California. In summarizing the breeding habits Dixon says:

From "sign" and tracks left in the snow, it is evident that most of the mating takes place at night.

During the rutting season I have followed mule deer about for days at a time in freshly-fallen snow, and have found that the normal mating practice is as follows: The most virile bucks are those that are just reaching maturity. Such bucks may, in some cases, be three-pointers, although the majority have acquired the fourth tine or point to each antler. My field studies of deer in Yosemite and in the Sequoia region, which have extended over a number of breeding seasons, have shown that in each season 90 per cent of the effective mating was accomplished by such dominant bucks. The usual procedure is as follows: As soon as their antlers become hardened and are freed of velvet, the bucks stage a series of combats which demonstrate which bucks are dominant and which are the weaker individuals. Through such elimination contests, a practical understanding is reached among all the bucks as to which is superior, and each buck learns his proper place. In most instances, the weaker bucks give way to their superiors whenever they appear on the scene.

The oestrus period in female deer varies, so that all the does are not ready to mate at the same time. When the pre-oestrus period is reached by a doe, she is singled out and closely followed by one of the dominant bucks until she is ready to mate. This "running" of does by bucks may extend from two to five days and is often confused with actual mating, which takes place subsequently as the final chapter in the mating episode. Mating having been accomplished, the "herd" buck hunts up a new doe and runs at her side until she is ready to mate.

There are about eighty photographs, most of them very good, and all of them aptly chosen, and there are three tables showing the trees, shrubs, and herbs known to be used for food by this species. There is an index.



THE AMERICAN EAGLE. *A Study in Natural and Civil History.*

By Francis H. Herrick. D. Appleton-Century Co., New York. \$3.50. 8½ x 5½; xx + 267 + 31 plates; 1934.

Professor Herrick was a pioneer in the precise and detailed scientific study of bird behavior. The present volume is a worthy capstone to his former achievements in this direction. The American bald

eagle (*Haliaeetus leucocephalus*) is obviously not an easy subject for intimate study, but in 1926 Professor Herrick built a 90-foot steel tower 38 feet away from and overlooking an eagle's nest at Vermilion, Ohio. From the pent-house on the top of this observation tower were made the records and photographs that form the substance of this book. It is a fascinatingly interesting and valuable contribution to zoology and comparative psychology that must form a part of every well-rounded biological library.

After the completion of the zoological discussion the last five chapters are devoted to the historical and political matters with reference to which the eagle has served as an emblem. While these chapters are interesting and scholarly, we cannot escape the feeling that it would have been better strategy to have published them as a separate book rather than as a somewhat unrelated appendage to a sound and fine contribution to zoology.

The photographic illustrations merit especial commendation, as does also the detailed and expertly constructed index.



WESTERN DUCK SICKNESS: A Form of Botulism. U. S. Department of Agriculture Technical Bulletin No. 411.

By E. R. Kalmbach, with Bacteriological Contributions by Millard F. Gunderson.

U. S. Government Printing Office, Washington. 10 cents. 9½ x 5½; 82; 1934 (paper).

Clostridium botulinum, type C, was shown to be the cause of an extremely destructive disease affecting migratory water fowl in the Western States. The lines of evidence were:

(1) the similarity of the clinical picture of the disease in the field with that produced experimentally by the administration of the toxin of pure cultures of type C *botulinum*; (2) the frequent recovery of the causative organism from the tissues of affected birds in distinction from its absence from the tissues of healthy birds; (3) the demonstration in the field of the toxin of type C *botulinum* in foods and water commonly ingested by birds; and (4) the fact that the incidence, course, and disappearance of duck sickness in the field conforms to the influence of environmental factors in a manner highly suggestive of botulism.

An estimated loss of a quarter of a million birds at the north end of Great Salt Lake in the summer and fall of 1932 points to the current importance of the malady as a destroyer of wild life. Not only

ducks but a multitude of other birds succumb: at present the list of known victims comprises 69 species, in 21 families of wild birds.

Apparently, man is immune to the disease. There is an annotated list of the 69 species of birds affected and a bibliography.



LES POISSONS ET LE MONDE VIVANT DES EAUX. *Études Ichthyologiques et Philosophiques. Tome Septième. L'Abîme des Grands Fonds Marins.*

By Louis Roule. Librairie Delagrave, Paris. 42 francs (paper); 70 francs (leather). 10 x 6½; 326 + 16 plates; 1934.

LA VIE DES REPTILES DE LA FRANCE CENTRALE. *Cinquante Années d'Observations Biologiques.*

By Raymond Rollinat. Delagrave, Paris. 75 francs (paper); 110 francs (cloth). 10 x 6½; 342 + 35 plates; 1934.

The first of these two books is the seventh volume of a work on fishes and other water animals which will eventually comprise nine volumes. This present one is devoted to deep sea fish.

The second book here noted gives a résumé of the author's observations, covering a period of fifty years, on reptiles indigenous to Central France. The observations were made on specimens housed in his own garden. They include one species of turtle, five of lizards and seven of snakes.

Both books are written in an interesting manner, and are illustrated profusely with text figures, photographs and colored plates. Neither volume is provided with an index, but this lack is partly met by detailed tables of contents. They belong to a commendable series of natural history books put out by the publishers.



HVALRÅDETS SKRIFTER. *Scientific Results of Marine Biological Research. Nr. 9. Pelagic Whaling in the Antarctic. IV. The Season 1933-34.*

By Johan Hjort, J. Lie and Johan T. Ruud. With a note on: *Limits of the Pack-Ice in the Antarctic in the Area Between 40° W and 110° E*, by H. E. Hansen. Edited by Uni-

versitetets Biologiske Laboratorium. Jacob Dybwad, Oslo. 10½ x 7; 59 + 7 plates; 1934 (paper).

Another number in this fine series dealing with the whaling industry. The present volume analyzes the catch and yield of whale oil for the 1933-34 season in Antarctic waters. The study is concerned with estimating whether the current practices in the whaling industry are adequate to secure the greatest economic return without depleting the whale population. The authors feel that this is being accomplished. The yield from fin whales and sulfur whales is converted into proportions of blue whales and the determination of these fractions must be an important step in the work. The data and calculations upon which the present converting factors are based are given in an earlier paper of the series.

The second paper in this volume shows the limits of the Antarctic ice pack for each year from 1929 to 1934 with the exception of 1931 when there were no Norwegian expeditions to the Antarctic ice.



THE NATURE OF A BIRD'S WORLD.

By Eliot Howard. University Press, Cambridge; Macmillan Co., New York. \$2.50. 8½ x 6; vii + 102; 1935.

This is a provocative essay on the extent to which field observations can be used as evidence in the analysis of the psychological processes of that class of vertebrates which "seems to mingle the blindness of an insect with the intelligence of an ape." The author is a well-known ornithologist who is at the same time a philosopher. His main concern here is endeavoring to account for the continuity that runs through the various actions of birds. It must not be difficult to explain specific types of behavior as due to instincts or hormones, at any rate many people seem to find it easy, but Howard has taken a bolder course and has outlined a larger problem. What sort of unitary principle connects the discrete activities of choosing and defending a territory, breeding, nest-making, and brooding? Obviously, there must be some link, since the same individual passes through these engrossing

activities, and Howard has a partial answer.



ANGLING WAYS.

By E. Marshall-Hardy. Herbert Jenkins, London. 7s. 6d. net. $7\frac{1}{2} \times 4\frac{1}{2}$; 305; 1934. English Isaak Waltonians will undoubtedly cheer this book for it gives much valuable and entertaining information on the technique of British Isles fishing. The material covered runs from straight ichthyology to philosophy (which is not all fishy) with particular emphasis attached to the "how" of angling. The author originally published the material as articles in the London *Evening News*.

American anglers, while not clicking to such names as "roach," "bream," "grayling," and "barbel," will nevertheless find the book well worth reading—and it may help them catch more "bass," "pike," "trout" and "musky."



THE HUNGARIAN PARTRIDGE IN THE GREAT LAKES REGION. *Bulletin No. 5.*

By Ralph E. Yeatter. School of Forestry and Conservation, University of Michigan, Ann Arbor. 35 cents. 9×6 ; 92; 1934 (paper).

Introductions of the European partridge into this country for game purposes have in part proved successful, but in numerous cases have been complete failures. The life habits, food and feeding habits from field observations and stomach analyses, mortality factors, and population fluctuations were all carefully studied by the author in the hope of solving this mystery. He concludes that the species is better adapted to agricultural conditions than our native game kinds, but it would increase more rapidly if safer nesting places were provided since the greatest losses occur as a result of mowing and other agricultural activities during the nesting period.



WILD ANIMAL MAN. *Being the Story of the Life of Reuben Castang.*

By R. W. Thompson. William Morrow

and Co., New York. \$3.00. $8\frac{1}{2} \times 5\frac{1}{2}$; 296 + 10 plates; 1934.

A story of the life of one of the great animal trainers of our times. An Englishman, with animal training a family tradition, Reuben went at the age of 13 to Hamburg where he was apprenticed to the Hagenbeck Company and worked with animals straight from the jungle. In 1900 he brought Hagenbeck's circus to America. Chimpanzees ultimately became his favorite animals and he has appeared before many people and in the films with some of the twenty-nine chimpanzees which he himself has captured alive in the jungle and trained. Mr. Thompson has produced a highly entertaining book. It has a few illustrations but is not indexed.



NATURAL HISTORY OF VERTEBRATES (*Except Birds*). *A Laboratory and Field Guide. Revised.*

By Frank N. Blanchard. Edwards Bros., Ann Arbor, Mich. \$3.00. $11 \times 8\frac{1}{2}$; ii + 82 + extra copies of forms; 1935.

The biologist who is interested in really scientific natural history has now a fine manual to guide his studies. This volume contains keys for classifying the vertebrates, notes on habitat and environmental conditions and excellent bibliographies. In addition to the strictly field studies there are very good directions for the laboratory study of material collected. This is a fine piece of work from all points of view.



LA CHASSE DES ANIMAUX A FOURRURE AU CANADA.

By Benoit Brouillette. Gallimard, Paris. 30 francs. $9 \times 5\frac{1}{2}$; xvi + 202 + 24 plates; 1934 (paper).

Hunting and trapping of fur-bearing animals is still an important Canadian industry. The author reviews its historical origin and describes the physical and climatological aspects of the country in relation to the animals, the routes of the professional hunters and trappers, their mode of life and the economic value of their products. The author's vivid style adds much to the feeling of adventure that

this subject inevitably arouses in the reader. There is a lengthy bibliography.



NEW ZEALAND BEETLES AND THEIR LARVAE. *An Elementary Introduction to the Study of Our Native Coleoptera.*

By G. V. Hudson. G. V. Hudson, Hillview, Karori W. 3, Wellington, New Zealand. 25 shillings. $8\frac{1}{2} \times 5\frac{1}{2}$; 236 + 17 plates; 1934.

As implied by the title this volume is *sensu stricto* an annotated, taxonomic list of the Coleoptera of New Zealand. The material is organized by families with all genera and species completely indexed at the end of the book. While not of great interest to the American specialist the volume will undoubtedly reach the handbook stage for New Zealand entomologists.



INFANTS OF THE ZOO.

By E. G. Boulenger. E. P. Dutton and Co., New York. \$2.50. $8\frac{1}{2} \times 6\frac{1}{2}$; xiv + 145; 1934.

This is an excellent volume for school libraries. The author writes interestingly on many things pertaining to the difficulties of rearing young animals. His subjects are mammals, birds, reptiles, amphibians and fishes, chiefly those that were born in two English zoological gardens. A valuable addition to the volume are the fifty photographs showing the babyhood of many of these animals.



TERMITES AND TERMITE CONTROL. *Second Edition, Revised.*

By Charles A. Kofoed, Editor-in-Chief; S. F. Light, A. C. Horner, Merle Randall, W. B. Herms, Earl E. Bowe, Termite Investigations Committee Editorial Board. University of California Press, Berkeley. \$5.00. $9\frac{1}{2} \times 6\frac{1}{2}$; xxvii + 795; 1934.

A review of the first edition of this report has already appeared in this REVIEW. The present edition has been thoroughly revised and additional material added, also an index (which was omitted in the first edition). The book is intended primarily for biologists, architects, engineers, con-

tractors, building inspectors, and users of wood, but the householder will also find it highly useful in helping him to decide whether he is being imposed upon by the too energetic salesman of insecticides.



THE SPINY DOGFISH. *A Laboratory Guide.*

By Alvin R. Cahn. The Macmillan Co., New York. \$1.10. $7\frac{1}{2} \times 5$; xii + 94; 1934.

This seems to be not a new edition but a reprinting of the 1926 edition which was reviewed in these columns, Volume 2, page 572. Since no change can be discovered between the two volumes there seems to be nothing to add to the earlier review.



THE EXTERNAL ANATOMY OF THE PARLATORIA DATE SCALE, PARLATORIA BLANCHARDI TARGIONI TOZZETTI, WITH STUDIES OF THE HEAD SKELETON AND ASSOCIATED PARTS. U. S. Department of Agriculture Technical Bulletin No. 421.

By F. S. Stickney. U. S. Government Printing Office, Washington. 10 cents. $9\frac{1}{2} \times 5\frac{1}{2}$; 67 + 1 plate; 1934 (paper).

A thorough study of the external anatomy and endoskeleton of the head and associated parts for all instars of both sexes of the *Parlatoria* date scale. This is the most dangerous insect attacking palms in the date growing region of the United States.



TIERE wie sie wirklich sind. Ein Bilder- und Lesebuch für Jedermann.

By L. Heck. Paul Parey, Berlin. 4.80 marks. $9\frac{1}{2} \times 6\frac{1}{2}$; 120; 1934.

The main attraction of this book is a series of excellent photographs of mammals and birds taken in the Berlin Zoo. It is interspersed with short, descriptive texts about the animals depicted, stressing the unique features of each. The author was for many years director of the Zoo.



FIELD BOOK OF INSECTS of the United States and Canada, Aiming to Answer Common

Questions. Third Edition, Rewritten to Include Much Additional Material.

By Frank E. Lutz. G. P. Putnam's Sons, New York. \$3.50. 6 $\frac{3}{4}$ x 4; vi + 510; 1935.

An old, esteemed friend brought up to date. This is a book to be included, along with Gray's *Botany*, in the equipment of the natural history student.



BOTANY

THE STRUCTURE AND REPRODUCTION OF THE ALGAE. *Volume I. Introduction, Chlorophyceae, Xanthophyceae, Chrysophyceae, Bacillariophyceae, Cryptophyceae, Dinophyceae, Chloromonadineae, Euglenineae, Colourless Flagellata.*

By F. E. Fritsch. University Press, Cambridge; Macmillan Co., New York. \$8.00. 8 $\frac{1}{2}$ x 5 $\frac{1}{2}$; xvii + 791; 1935.

Until now there has been no adequate account of the morphology of the algae published in English, and Professor Fritsch's scholarly monograph will be welcomed by everyone working on the Protista.

The two volumes in which I propose to accomplish this task are planned to deal essentially with morphological features, and points relating to the physiology and ecology of the Algae have been included only where their consideration appeared relevant to an understanding of the main subject-matter. Nor is this in any sense a taxonomic work. The outlines of classification given under the individual groups are intended merely to afford a synopsis for the reader, and taxonomic problems have only been discussed where they are of general morphological interest. Some attempt has been made, without entering into detail, to deal with the numerous cytological papers that have been published during the present century, but this has certainly been the hardest part of my task.

This volume treats eight of the eleven classes of algae Fritsch recognizes, namely the Chlorophyceae (Isokontae), Xanthophyceae (Heterokontae), Chrysophyceae, Bacillariophyceae, Cryptophyceae, Dinophyceae, Chloromonadineae, and the Euglenineae. "Unless purely artificial limits are drawn, the designation alga must include all holophytic organisms (as well as their numerous colourless derivatives) that fail to reach the higher level of differentiation characteristic of the arch-

egoniate plants." Accordingly, the Flagellata are treated in this volume, also.

Many things have been done to make this a reference book of uncommon usefulness to students of the Protista. There are nearly 250 illustrations, most of them occupying a full page, taken from the literature. Extensive bibliographies covering the period 1890 to 1933 appear at the end of the discussion of each taxonomic group and each citation is indexed in the author index. There is an excellent subject index.



THE FLORA OF THE NIAGARA FRONTIER REGION. *Ferns and Flowering Plants of Buffalo, N. Y., and Vicinity.*

By Charles A. Zenkerr. Buffalo Society of Natural Sciences, Buffalo. \$2.00. 9 $\frac{3}{4}$ x 8 $\frac{1}{2}$; x + 328 + folding map; 1934.

The area included in this floristic and ecological survey lies within a radius of about 50 miles of Buffalo, New York, in a very interesting physiographic region which is well described. To the north and to the west are Lakes Ontario and Erie and these so ameliorate the climate that the Austral, or temperate zone, flora lies on the north and the Boreal, or sub-arctic, flora lies on the margin of the Allegheny Plateau to the south. Most of the region was glaciated and special attention is given to the flora of a district which was not glaciated.

Besides a description of the geological and meteorological features of the region the introductory section of 67 pages gives a brief account of the botanical reports of early explorers and of the economic history of the region insofar as it bears upon deforestation and the use of the land for agriculture. The greater part of the book, about 200 pages in length, is given over to a listing by families of the 563 genera and the 1,702 species of vascular plants found in this region. For each species there is brief mention of its frequency of occurrence throughout the region and of its relative abundance in the places where it does grow. The type of soil on which it is found is also noted and there is a short list of local stations for each species. The ecology of the region is discussed in

detail in the last section of the book and plant lists and general descriptions are given for each of the major plant communities.

Not counting the scattered explorations of early taxonomists beginning with Peter Kalm in 1750, serious botanical work on the flora of this region has been in progress since 1862 and the publication of this book is an achievement for which the Buffalo Society of Natural Sciences and the author deserve to be congratulated. Everything possible has been done to make this a useful reference book; there are numerous excellent maps showing both geology and topography, the photographs of flowering plants and of ecological communities are numerous and are unusually good, the bibliographic references to other floras and to other sources are adequate, and there is an index to genera, families, and common names.



POT CULTURE TESTS OF FOREST SOIL FERTILITY. *With Observations on the Effect of Varied Solar Radiation and Nutrient Supply on the Growth and Nitrogen Content of Scots and White Pine Seedlings. The Black Rock Forest Bulletin No. 5.*

By Harold L. Mircbell. *The Black Rock Forest, Cornwall-on-Hudson, N. Y.* \$2.00. 9 x 6; xi + 138 + 2 folding charts; 1934 (paper).

The primary object of this experiment was to make a biological test of the various soils found within a forest in the Hudson Highlands of New York State. The first step was to calibrate, as it were, tree seedlings so that from their response to a soil sample the availability of the several mineral nutrients could be deduced. This prompted a very careful physiological experiment on the growth of Scots pine and white pine seedlings under different intensities of light and with different supplies of mineral salts. The quantitative data thus obtained were capably analyzed. Among other things, it was found that the density of the blue-green color of white pine seedlings was directly proportional to the amount of nitrogen supplied, and that a deficiency of phosphorus caused a purple needle color. The

second step was to grow seedlings in samples of the soil to be tested, and to test the soil for mineral deficiency in two ways. If, for example, a possible deficiency of nitrogen were suspected, salts containing the elements P, K, Ca, Fe, Mg, and S were added to the soil sample and growth was compared with growth in a control soil sample which received all these elements and nitrogen in addition. Seedling color provided an additional test. In samples of soil from the four major soil types of the forest Ca and K were abundant, and only an exposed ridge soil lacked N. All soils were deficient in P. This publication deserves the attention of everyone interested in the mineral nutrition of plants. The experimentation was admirably executed and the results are well presented in full detail. There is a bibliography covering six pages.



DIE STOFFAUSSCHIEDUNG DER HÖHEREN PFLANZEN. *Monographien aus dem Gesamtgebiet der Physiologie der Pflanzen und der Tiere. Band 32.*

By A. Frey-Wyssling. Julius Springer, Berlin. 28 marks (paper); 29.40 marks (cloth). 8½ x 5½; xii + 378; 1935.

Frey-Wyssling's initial definition indicates the scope of his monograph:

Ausscheidungsstoffe can be defined as materials which are secreted by the living protoplasm and which are not used again in metabolism. In contrast to these are reserve substances which are also lifeless deposits but only temporarily eliminated from metabolism. According to this concept structural substances such as mineral deposits and organic inclusions like resin and rubber which finally are eliminated from metabolism belong to the *Ausscheidungsstoffe* while the reserve substances like starch, aleuron, fat, and certain hemicelluloses can be remobilized.

The first hundred pages deal with the submicroscopical structure of the cell wall, and the discussion of the data obtained by the use of X-rays, polarized light, and other optical methods is enough to make this a valuable book. The physiological aspects of the formation of cell walls are discussed in the next fifty pages. The next 120 pages deal with the physical chemistry, physiology, and cytology of the deposition of minerals in plants. The last hundred pages concern excretion and

secretion. It makes a valuable reference book for plant physiologists and its usefulness is increased by an extensive bibliography and a good index.



KEY TO THE RUSTS OF THE PACIFIC NORTH-WEST. *University of Washington Publications in Biology, Volume 3.*

By J. W. Hotson. *University of Washington Press, Seattle.* \$1.50. 10 x 7; 193; 1934 (paper).

Hotson has done a very useful piece of work in a creditable manner.

Many rusts are so highly specialized that they confine their activities to relatively few species of the host, some to a single species, others to different species in the same genus; rarely do they produce the same spore-forms on more than one host family. Utilizing this characteristic of rusts an attempt has been made to identify them by means of the host. The general plan of the paper has been to list all the rusts reported for the four states, Washington, Oregon, Idaho, and Montana under the family and genus on which they occur. These families and the genera within the families are arranged alphabetically. Under each host-genus an attempt has been made to separate the various rusts by means of a Key.

There ought to be similar surveys for all sections of the country but in their absence this book will probably prove to be a valuable aid to mycologists interested in the Uredinales found in the northern half of the United States. There are two indexes, one for host names and one for rust names.



DER ABBAU. *Eine entwicklungsgeschichtliche Studie zum Senilitäts- und Fortpflanzungsproblem.*

By Franz Ragaller. *Gustav Fischer, Jena.* 5.60 marks. 9½ x 6½; 85; 1934 (paper). This is a general and theoretical discussion of the results of a ten-year investigation of the problem of degeneration in a particular variety of potatoes—a problem that horticulturists, plant breeders, and botanists generally have struggled with for years. Potato varieties "run out," as the common phrase goes. But why they degenerate has never been clearly explained. Other vegetatively propagated forms do not, as witness, for example, the Baldwin apple.

Dr. Ragaller has not finally solved the problem. But he has put it in better order and more sharply analyzed the *Fragestellung* than anyone before him. His discussion is of great interest and importance to the general biologist. He argues with cogency and force, and in fact seems to us to prove, that the problem of degeneration is one that never will be solved by the "crucial experiment" type of research, however carefully and ingeniously planned and executed. The reason is that degeneration is a combined ecological, senility, and disease problem *all in one*, the several aspects being indissolubly united in space, time and essence.



PRACTICAL PLANT ANATOMY. *An Elementary Course for Students.*

By Comyns J. A. Berkeley. *University of London Press, London.* 3 shillings. 7¼ x 4½; 112; 1934.

There is no better book than this for people taking up microscopy as a hobby or for teachers of general botany or plant histology who need a little guidance in planning their laboratory work. The use of the microscope and the various operations involved in cutting, staining, studying, and preserving free-hand sections of plant tissues are explained in minute detail, and this manual can be recommended as a trustworthy guide in these matters. There are about a hundred laboratory exercises arranged in order of difficulty and these include most of the kinds of material usually assigned to students in courses of this kind. These laboratory instructions are quite complete. There is a table of the simple microchemical tests and directions for preparing the reagents are given.

Teachers should find the check list of plant materials, their sources and manner of preservation, particularly useful. The use of the microtome is not discussed. There is an index.



THE MYSTIC MANDRAKE.

By C. J. S. Thompson. *Rider and Co., London.* 15 shillings net. 8½ x 5½; 253 + 8 plates; 1934. No plant has been the subject of such

curious lore or has been so extensively used in mystic rites as has the mandrake. Because of the resemblance of the root to the human form it was believed to possess occult properties which could cause it to become animated. Many treatises have been written on its virtues as an anaesthetic, as a love charm, as a cure for sterility, its power to invigorate the aged as well as its demoniacal and evil powers. The author, honorary curator of the historical collection of the Museum of the Royal College of Surgeons of England, has given an interesting and authentic history of this plant. The volume is illustrated and indexed.



DICTIONARY of Terms Relating to Agriculture, Horticulture, Forestry, Cattle Breeding, Dairy Industry and Apiculture. In English, French, German and Dutch.

Compiled by T. J. Bezemer. *The Williams and Wilkins Co., Baltimore.* \$8.00. 8 x 5½; vii + 1061; 1934.

This polylingual dictionary of words and phrases used in the literature of agriculture, horticulture, forestry, and animal husbandry, has a great deal of usefulness in supplementing the standard dictionaries hitherto available. For each one of the four languages, English, German, Dutch and French, there is a separate dictionary giving the equivalents of technical terms in the three other languages without further definition. The names of plants and animals are also rendered by their Latin equivalents. It is a very satisfactory piece of work, on the whole. It overlaps literary dictionaries very little, gives satisfactory idiomatic equivalents in most cases, and is reasonably complete.



MORPHOLOGY

ELEMENTARY HUMAN ANATOMY. *Based on Laboratory Studies.*

By Katharine Sibley. *A. S. Barnes and Co., New York.* \$4.50. 9½ x 6½; xx + 360; 1935.

This undergraduate textbook of human anatomy

is written as a foundation course for the study of kinesiology and physiology and for the students and teachers of physical education. The writer has placed special emphasis on osteology, syndesmology, myology and the nervous system to aid the teacher of corrective gymnastics and the physiotherapist in muscle examination and muscle reeducation.

The plates, many of them colored, have been taken from the standard atlases of human anatomy and appear to have been judiciously selected. The text explains the methods of demonstrating on living subjects the various structures of the human body and their mode of action. Detailed, technical, anatomical descriptions are not given. There are more than 200 plates, excellently reproduced, and there is an excellent index.



AIDS TO EMBRYOLOGY. *Second Edition.*

By Richard H. Hunter. *William Wood and Co., Baltimore.* \$1.25. 6½ x 4; viii + 172; 1934.

The purpose of this small book, according to its author, is to give the medical student enough of a survey of human development so that he will be able to interpret common abnormalities experienced in the dissecting-room and obstetrical wards. The book is divided into twelve short chapters dealing with the development of specific organs and systems. The work will probably be useful to students and physicians who wish to review some of the essentials of mammalian embryology with a minimum expense of time. It is clearly written in summary style.



OUR VANISHING HAIR. *A Dissertation on Human Hair Production with Special Reference to Premature Baldness.*

By Charles Nessler. *Alwyn-Schmidt Publishing Co., New York.* \$2.00. 8 x 5½; 140 + 8 plates; 1934.

The author again expounds some quaint theories about hair. Premature baldness is said to result solely from the custom of periodic hair trimming. Since cutting the hair removes its weight, the hair follicle becomes weak and gradually loses its gripping power until in adulthood it can no longer hold on to even the finest

and lightest hairs. Another new and somewhat startling idea is that hair migrates. Since the hair urge is denied by repeated trimmings a full expression on the head it migrates in man to the chest and limbs. The author limits the hairy regions arising as secondary sexual characteristics to armpits, pubic region and lower face. Growth of hair on chest and limbs is correlated in his belief with loss of hair on the head. He has nothing to say about inheritance of baldness.



GRUNDRISSE DER CYTOLOGIE.

By *Lothar Geitler*. *Gebrüder Borntraeger, Berlin*. 19.20 marks (paper); 21 marks (bound). 10 x 6½; viii + 296; 1934.

The examples of cytological phenomena illustrated and discussed in Geitler's introductory textbook of cytology are drawn from all parts of the plant and animal kingdoms and Geitler's own field, the Protista, is also well represented. Fittingly enough, the book is dedicated to Karl Belar, for Geitler has been very much influenced by his former associate and has used many of his illustrations. The illustrations, more than 200 in all, have been taken from the literature and from unpublished work and are both well chosen and well reproduced. Full advantage has been taken of the comparative method in the description and analysis of cytological phenomena. There are few bibliographic citations but there is a good index.



A HISTORY OF EMBRYOLOGY.

By *Joseph Needham*. *The Macmillan Co., New York*. \$4.00. 9½ x 6½; xviii + 274 + 16 plates; 1934.

This is essentially an elaboration of the early part of the two volume work on *Chemical Embryology* by the same author which was published in 1931. There is a good deal of new material added but the general order and the topics considered are the same here as in the earlier publication. This book represents a very interesting and scholarly addition to the field of the history of biology.

PHYSIOLOGY AND PATHOLOGY

THE VITAMIN B₁ REQUIREMENT OF MAN.
By *George R. Cowgill*. Published for The Institute of Human Relations by Yale University Press, New Haven. \$4.00.

9 x 6; xix + 261 + 4 plates; 1934.

Professor Cowgill is trying to put together the results of animal experimentation on vitamin B₁ requirements in such a way that the knowledge thus gained may be more directly applied to the study of human dietaries. The absolute amount of any vitamin required by any animal might be expected to bear some relation to the animal's body weight. For some time, the relation was supposed to be a constant and direct one and grams of vitamin per gram of body weight of pigeon and rat were used interchangeably. But it has been found that this is not altogether true, at least for vitamin B₁. Pigeons seem to require more vitamin B₁ per unit of body weight than do dogs.

Since it is impossible to subject humans to the rigorous experimentation necessary to determine such a relationship, Cowgill proposes to extend knowledge gained from animal experimentation. This necessitates determining the relation between body weight and vitamin requirement in a way that will hold from one species of animal to another. Cowgill's own thesis is that the vitamin B₁ required is a function of metabolism. His first approach is that the vitamin B₁ required is directly proportional to body surface (determined as body weight^{2/3}) but this doesn't seem to work very well in giving comparable results. So then he tries different powers of body weight and finally reaches the conclusion that vitamin B₁ is directly proportional to the 5/3 power of body weight. This seems to be a very important fact and one that should be very carefully and accurately determined. We should like to see this relation determined by other and more efficient statistical techniques.

A subject index would increase the usefulness of the book.



THE PATIENT AND THE WEATHER. *Volume II, Autonomic Dysintegration. Volume III, Mental and Nervous Diseases.*

By William F. Petersen and Margaret E. Milliken. Edwards Bros., Ann Arbor, Mich. Vol. II, \$5.00; Vol. III, \$6.50. 10 $\frac{1}{2}$ x 8 $\frac{1}{2}$; Vol. II, xx + 530; Vol. III, xvi + 375; 1934.

The author revives the Hippocratic concept of the influence of weather conditions on disease manifestations by emphasizing the effect of meteorologic changes on the autonomic nervous system. In brief his point of view is that vasomotor instability has not only an important rôle in the progress of certain diseases or in determining predisposition to them, but also in the degree of susceptibility to clinical manifestations of infections. The instability, meaning abnormal fluctuations in vasoconstriction and vasodilation is, in the author's opinion, directly related to barometric pressure, temperature, humidity, etc., and shown by changes in blood pressure, blood pH, K/Ca, CO₂, and cholesterol contents. It is also associated with the individual somatic habitus.

In Volume II the author discusses the effect of meteorologic alterations on the unstable individual relative to headaches, epilepsy, eclampsia, mucous colitis, gastric ulcers, certain allergic conditions, arthritis, Ménière's disease, etc.

In the first part of Volume III he amplifies his previous conclusions and describes the different meteorologic conditions in the United States in relation to the geographic distribution of congenital physical malformations; the seasonal distribution of the conception of mentally superior and inferior individuals, of manic depressives and schizophrenics; the seasonal incidence of suicide. One of his tentative conclusions is that conceptions during the meteorologically stable months produce more often normal or dull-witted individuals while those occurring during the unstable months more frequently produce insane or mentally superior men. The second part of this volume is dedicated to different forms of psychosis, multiple sclerosis, tabes and paresis, poliomyelitis and meningitis.

The author is guarded in his conclusions and justly so since sufficient evidence is not given. For each disease condition he presents a few selected cases with detailed medical history, and physical and bio-

chemical examinations, meteorologic charts and in some instances anthropometric data. It is a very interesting study and important from the standpoint of human constitution but it will necessitate further investigation both experimentally and statistically.



DE VENARUM OSTIOLIS, 1603, OF HIERONYMUS FABRICIUS OF AQUAPENDENTE (1533?-1619). *Facsimile Edition.*

With Introduction, Translation and Notes by K. J. Franklin. Charles C. Thomas, Springfield, Ill. \$3.00. 9 $\frac{1}{2}$ x 6; 98 + 3 plates; 1933.

When Boyle asked Harvey what had led him to think of a circulation of the blood, the latter answered

that when he took notice that the Valves in the Veins of so many several Parts of the Body, were so Plac'd that they gave free passage to the Blood Towards the Heart, but oppos'd the passage of the Venal Blood the Contrary way: He was invited to imagine, that so Provident a Cause as Nature had not so Plac'd so many Valves without Design: and no Design seem'd more probable, than That, since the Blood could not well, because of the interposing Valves, be Sent by the Veins to the Limbs; it should be Sent through the Arteries, and Return through the Veins, whose Valves did not oppose its course that way.

Now from 1600 to 1602 Harvey had studied at Padua under the celebrated anatomist Fabricius of Aquapendente, who was the first to describe the valves of veins in detail. Thus although Fabricius was prevented by his adherence to the ideas of Galen from drawing those inferences which his pupil later made, his discovery was an important step in the process. Dr. Franklin gives a reduced facsimile and a translation of Fabricius' description of the veins, as well as a graphic brief account of his life, a summary of previous work on the vein valves, and a history of the theater of the school of anatomy at Padua with architectural drawings of the theater, still existing, which Fabricius himself caused to be built.



A NEW DEAL IN LIQUOR. *A Plea for Dilution.*

By Yandell Henderson. Also a Reprint-

ing of *An Inquiry into the Effects of Ardent Spirits upon the Human Body and Mind*, by Dr. Benjamin Rush. Doubleday, Doran and Co., Garden City, N. Y. \$2.00.

8 x 5½; x + 239; 1934.

Professor Henderson starts with the thoroughly sound assumption that Americans are going to continue to drink alcoholic beverages. For him, the liquor problem resolves itself into the problem of weaning people away from whisky and other concentrated alcoholic beverages and of substituting beer and other wholesome and harmless alcoholic beverages. There are two obstacles to this program, the stupidly perverse taxation policy which makes whisky cheap and beer expensive in terms of their alcohol content, and the practice of selling beer and whisky over the same bar. Professor Henderson's position throughout the book is that of a toxicologist analysing a problem in which public health is involved. He addresses himself to people concerned with the legal control of the sale of alcoholic beverages, presents briefly but adequately and fairly the scientific and historical data that bear most directly upon the problem, and concludes with a program he believes will be conducive to temperance. In an appendix of about 30 pages he reprints a pamphlet first published in 1784 by Dr. Benjamin Rush who set himself the same problem as Henderson. There is an excellent index.



THE COMPARATIVE PHYSIOLOGY OF THE CONDITIONED MOTOR REFLEX. *Based on Experiments with the Pig, Dog, Sheep, Goat, and Rabbit. Comparative Psychology Monographs, Vol. 11, No. 1, Serial No. 51.*

By H. S. Liddell, W. T. James, and O. D. Anderson. Johns Hopkins Press, Baltimore. \$1.50. 10 x 6½; 89; 1934 (paper).

The human nervous system is susceptible of disorders which are directly caused by social maladjustment. The normal adult assumes social responsibilities and conforms to an intricate schedule of habits. When he is able to discharge his obligations successfully and hence to maintain a stable system of behavior, mental life pursues a healthy course. But social life may become too intricate. An individual may imperceptibly impose upon himself too many duties. His life becomes too regimented and self-imposed restraints bulk dangerously. Such an individual has cut off his avenues of escape and can no longer secure

adequate relief from dangerous nervous tension through evasion or procrastination. When serious predicaments arise a mental derangement may result because the individual has already been effecting intricate adjustments which have taxed his nervous capacity to the limit. The added demand calls for that which cannot be supplied, and nervous bankruptcy follows.

This monograph shows how such neurotic conditions may be produced in experimental animals. There is also a considerable amount of detail about the experimental procedure in conditioned reflex experiments.



REVUE D'IMMUNOLOGIE. *Tome 1, No. 1, Janvier 1935.*

Edited by Robert Debré, G. Ramon, Pasteur Vallery-Radot. Masson et Cie, Paris. Subscription: (6 numbers per year): France, 80 francs; foreign, 90 francs; single number 15 francs. 9½ x 6½; 112; 1935 (paper).

To bring before biologists and clinicians the more important work being done in the field of immunology and the practical application of many of the discoveries being made is the aim of this new journal. In its pages will be published original memoirs, articles bearing on actual problems of immunity, and critical reviews. The first number contains the following papers (in French): Immunity and immunization against typhus; position and actual state of the question, by Jules Bordet; Vaccination against diphtheria and tetanus by means of specific antitoxins and associated vaccines, now in practise, by G. Ramon; Comparison of provoked and spontaneous anaphylaxis, by Pasteur Vallery-Radot and G. Mauric; Mode of action of immunity created by diphtheria antitoxin; experimental study, by G. Ramon, Robert Debré and G. Séc; The problem of allergic migraines, by Jean Hamburger.



ALCOHOL AND ANAESTHESIA.

By W. Burridge. Williams and Norgate, London. 2s. 6d. net. 8½ x 5½; 65; 1934 (paper).

On the basis of his experiments the author

comes to the conclusion that alcohol exerts independent actions of both exaltation and depression on the same tissue at the same moment. Under the older theories of the physiology of alcoholic action Burrige claims it has been impossible to explain this fact which his collected data and interpretations fit quite nicely. In brief, the new theories developed in the book are "that central neurones are rhythmically active structures which possess two sources of potential for their energy manifestations and that the physiological basis of an idea is a group of nerve cells rhythmically active in unison."

The reader will have to keep awake if he is to find out what this book is about and why—however, he may take some comfort in one of the author's conclusions that the "intelligent and clean-minded" may be able to imbibe alcoholic liquors with benefit.



THE PHYSIOLOGY OF HUMAN PERSPIRATION.

By Yas Kuno. J. and A. Churchill, London. 12s. 6d. 8 x 5½; x + 268 + 6 plates; 1934.

The author, who is professor of physiology in the Manchuria Medical College, has devoted nine years to a study of the physiology of perspiration. The book contains a thorough survey of all important research in the subject up to the present, and a summary of the work done in his own laboratory. He points out that sweating is not as simple a physiological process as has heretofore been assumed. Sweating produced from emotional and sensory stimulation is controlled by a different cerebral center than that occurring as a result of high temperature. Sweating also has an important rôle as a physiological process, he believes.

The book is a thoroughly scholarly piece of work. There are 26 pages of bibliography devoted to papers published in the department and upon which the monograph is based.



STANDARD CLASSIFIED NOMENCLATURE OF DISEASE. *Second Edition.*

Compiled by The National Conference on Nomenclature of Disease; Edited by H. B. Logie. Commonwealth Fund, New York. \$3.50. 7½ x 4½; xxi + 870; 1935.

The first (1933) edition of this *Standard Classified Nomenclature of Disease* was reviewed in Vol. 8, p. 375.

The same general plan of classification of coding is followed in the new edition as in the old. . . . The most important changes will be found in the sections on endocrinology, neurology, diseases of the cardiovascular system, and diseases of the musculo-skeletal system; the latter two have been rewritten, not only to make them more complete and exact but to make reference easier. Errors and omissions have been corrected, and the Index has been enlarged by about two thousand items so as to facilitate cross reference between terms in common use and the terminology employed in the *Classified Nomenclature*. It now contains nearly 15,000 items.



RAPPORT SUR LE PÈLERINAGE AU HEDJAZ de l'Année de l'Hégire 1352 (A.D. 1934).

Conseil Sanitaire Maritime et Quarantenaire d'Égypte, Alexandria. Freec. 12½ x 9; 81 + 5 folding tables; 1934 (paper).

The annual pilgrimage to the Hedjaz has sent many hundreds of devout Mohammedans to the Moslem heaven what with cholera, typhoid, etc. In recent years the morbidity and mortality have greatly diminished. This statistical report issued by the Sanitary Council of Egypt explains this decrease and demonstrates again the benefits derived from strict sanitary measures. It deals with almost 10,000 pilgrims (circa 1/6 of the total) who came to the Hedjaz from Egypt or from other countries but passed through Egyptian parts and the Suez Canal. The pilgrims were given injections against typhoid, cholera and pest. Quarantine was established before the pilgrims were allowed to return and there they were given physical and laboratory examinations. The excellent results are immediately apparent from the many tables which summarize the data obtained from the reports of the health officers.



DAS GESUNDHEITSWESSEN BEI ARISTOTELES.

By Paul Kalbhoff. Ferd. Dümmler, Berlin and Bonn. 12.80 marks (paper); 14.80 marks (cloth). 9½ x 6½; xvi + 372; 1934.

Kalthoff expresses as one of his aims in writing this book the hope of "awakening in the medical man, historical, and in the philologist, medical, understanding." This is a compilation of what is written in the various works indisputably attributed to Aristotle, concerning various phases of hygiene and medicine. The chapter headings include social hygiene, exercise, clothing, climate, communicable and other diseases, anatomy, sexuality, psychiatry, medicinal plants, etc., etc. Numbers in the text refer to references given at the back of the volume which are complete even to page and column but at times the edition of the work used by the author is not made clear.

A short list of comparatively recent works on medicine and hygiene in ancient Greece and Rome is given in the introduction. The book has no index.



PHYSIOLOGIE ET PHYSIOPATHOLOGIE DU SYSTÈME RÉTICULO-ENDOTHÉLIAL.

By Albert H. Du Bois. *Masson et Cie, Paris.* 36 francs. 9½ x 6½; 204; 1934 (paper).

A critical review of the discoveries made between 1924 and 1933 relative to the reticulo-endothelial system. The first part which includes an excellent chapter on the morphology of the reticulo-endothelial system records the general experimental results regarding functional tests and vital fixation. The second part deals with the function of this system in normal and pathologic physiology; metabolism of pigments, lipoids, carbohydrates, water, proteins; the reaction to infectious diseases, phagocytosis and immunity. There follow chapters on the changes produced by different forms of therapy in disease. A comprehensive bibliography of 30 pages closes this fine work.



THE NUTRITIONAL ORIGIN OF CANCER.

By Edwin E. Ziegler. *Edwin E. Ziegler, Box 2193, Boise, Idaho.* \$2.50. 9 x 6; iv + 92; 1934 (paper).

The author believes that there is enough statistical evidence to show conclusively that the incidence of cancer is directly

proportional to the consumption of alkaline food. In European countries where a large quantity of alkaline foods are consumed there exist the highest death rates from cancer, and conversely primitive people, subsisting on a high protein and acid forming diet, have very little cancer. As cancer is thus a disease of civilization the best preventive measures would be to return to a primitive diet, high in acid forming foods and similar to that of our savage and nomadic ancestors.



HEALTH DENTISTRY FOR THE COMMUNITY. *A Study of the Present Needs and General Trends in the Provision of Community-wide Dental Care.*

By The Committee on Community Dental Service of the New York Tuberculosis and Health Association. *University of Chicago Press, Chicago.* \$1.00. 8½ x 5½; xiii + 85; 1935.

A survey of the existing conditions of dental health in large urban communities shows that there is a deplorable lack of proper dental treatment, particularly among school children. A summary of the dental findings among 1,000 patients of the white collar class also indicates that present dental care for adults is far below what it should be to maintain a healthy community. The survey points out the need for socialization of dentistry, and offers, in the concluding chapters, a good working program.



OLD AGE—Medically Considered.

A Series of Papers by Medical Authorities on the Physical and Dietetic Treatment of Diseases and Disabilities of Old Age. *Actinic Press, London.* 3 shillings net. 8½ x 5½; 96 + 2 plates; 1934 (paper).

These papers, originally published in the *British Journal of Physical Medicine*, deal with the diet, ocular diseases, dental disease, early prostatic obstruction, neuritis, sciatica and lumbago, cardio-vascular disease, deafness, kidney disease, skin affections, respiratory disorders, the importance of exercises and recreations, and physical treatment of cardio-vascular sclerosis.

POUR VIVRE CENT ANS ou l'Art de Prolonger ses Jours. Troisième Édition.

By A. Guénior. J.-B. Baillière et Fils, Paris. 14 francs. 7½ x 4½; 230; 1933 (paper).

When this third edition was published the author, a physician, was 101 years old. He regards the century mark as the "normal" life span and gives his reasons which are not very convincing. His advice on the means of attaining this age is the usual formula: temperance. It is to be presumed that the author himself followed a temperate regimen but there is no specific statement to this effect.



KONSTITUTION UND TUBERKULOSE IM KINDESALTER.

By Kurt Klare. Georg Thieme, Leipzig. 4 marks. 10 x 6½; 42; 1935 (paper).

The writer discusses briefly the constitutional types and bodily habitus of children in relation to their susceptibility to tuberculosis. He includes a series of selected cases with family history, patient's past history and the habitus but is unable to arrive at any definite conclusions regarding the relative influence of these factors.



LA PROTIDÉMIE ET LA PRESSION OSMOTIQUE DES PROTIDES. Recherches Expérimentales et Applications Cliniques.

By Antoine Codounis. Masson et Cie, Paris. 36 francs. 9½ x 6½; 212; 1934 (paper).

Methods of technique and detailed observations are given on experimental work with animals and clinical with man concerning the protein equilibrium of the blood and osmotic pressure in normal and diseased conditions. The bibliography covers 11 pages.



BIOCHEMISTRY

ÉLÉMENTS DE CHIMIE VÉGÉTALE.

By N. Wattiez and F. Sternon. Masson et Cie, Paris. 100 francs. 9½ x 6½; 729; 1935 (paper).

This is one of the best reference books on plant biochemistry to appear in recent

years. It has been written primarily to facilitate the qualitative and quantitative analysis of plant products, and several kinds of information and numerical data are concisely presented. Much use has been made of tabular data and the authors have shown no little skill in reducing physical, chemical, and pharmaceutical data to tabular form or to some other form of systematic presentation. Structural formulae are given for all substances and the formulae for the carbohydrates are in accordance with Haworth's findings. Prominence is given to color reactions for the ready recognition of specific substances and groups of substances and one section is devoted to the use of such methods in microscopy. In general, the text is meant to summarize the data of organic chemistry rather than to expound it for beginners. The bibliographies that follow each chapter are adequate and there is an excellent index.



INDUSTRIAL POSSIBILITIES OF SOME RESEARCH WORK DONE IN INDIA.

By Gilbert J. Fowler. Society of Biological Chemists, Indian Institute of Science, Hebbal P.O., Bangalore. Re. 1. 8½ x 5½; 42; 1934 (paper).

A brief description of the local commercial and industrial exploitation of the results of bio-chemical researches conducted at different Indian institutes and universities. The subject matter is classified in (1) researches resulting in permanent factories, (2) researches resulting in factory operations still in the initial stage, (3) researches resulting in factories now discontinued for various reasons, (4) researches not fully exploited, (5) researches which await commercial consideration. It appears that by stimulating scientific activity there are great possibilities for further economic development in India.



LABORATORY MANUAL OF PHYSIOLOGICAL CHEMISTRY. Third Edition.

By Meyer Bodansky and Marion Fay. John Wiley and Sons, New York. \$2.00 net. 9 x 6; vii + 274; 1935.

In volume 4, page 148 of the QUARTERLY

REVIEW OF BIOLOGY, is a review of the first edition of this manual. The present edition shows considerable change. The chapter on colloids has been omitted since the authors believe that adequate treatment of the subject cannot be included in a manual of the size of the present one. The order of some of the chapters and experiments has been changed and at many points additional material has been added. The table of atomic weights has been brought up to date.



DIE RÖNTGENSPEKTROGRAPHIE ALS UNTERSUCHUNGSMETHODE bei hochmolekularen Substanzen, bei Kolloiden und bei tierischen und pflanzlichen Geweben. *Handbuch der biologischen Arbeitsmethoden. Lieferung 436.*

By J. R. Katz. Urban und Schwarzenberg, Berlin. 20 marks. 10 x 7; 316; 1934 (paper).

This monograph is based on the lectures delivered to students of chemistry by the author every second year at the University of Amsterdam. The book is chiefly an elaborate description of technique, and is therefore, as the author admits, of little value unless used in conjunction with laboratory work. The work is very thoroughly done and contains descriptions of the best methods of X-ray for every kind of animal and plant tissue.



RECHERCHES EXPÉRIMENTALES SUR QUELQUES ESTERS DE LA CHOLINE.

By Maurice Villaret, L. Justin-Besançon and René Cachera. Masson et Cie, Paris. 38 francs. 10 x 6½; 254; 1934 (paper).

Here are offered the results of twenty years' experimental work on laboratory animals and man on the effects of different doses of some of the cholines, notably acetylcholine and methylacetylcholine, on the cardio-vascular and respiratory systems and gastric secretions. Charts, a three page list of works by the authors and co-workers, and an index are provided.



MIKROCHEMIE DES BLUTES. *Monographien aus dem Gesamtgebiete der Mikrochemie.*

By Friedrich Rappaport. Emil Haim und

Co., Vienna. 15 marks (paper); 16.80 marks (cloth). 9½ x 6½; xi + 206; 1935. A hand-book of blood analysis techniques given under the headings of principle of method, reagents to be used, the procedure, the method of calculating the result, an example worked out, and then some sort of interpretive remarks showing clinical conditions where the analysis at hand is to be used and what order of numerical values is to be expected.



SEX

WOMEN ON THEIR OWN.

By Olga Knopf. Edited by Alan Porter. Little, Brown and Co., Boston. \$2.75. 8½ x 5½; 306; 1935.

Dr. Knopf was born and educated in Vienna where she did a large part of her medical work until she came to New York in 1931. Although she served as a surgeon during the war and later practiced as a specialist in gynecology her main interest lay in medical psychology, and for the last ten years her work has been in this field. Her book is written for the average American woman. She does not always grasp the American viewpoint but she has produced a sane, sensible book which probably could be applied generally to women in any civilized country. She discusses woman in relation to her men friends, her women friends, and her fellow workers, choice of work, career, and marriage, women of the new era and the question as to whether marriage can solve a personality problem. There is some analysis of neurotic and psychopathic types but in the main the book is rather a guide to the normal woman in the solution of such ordinary difficulties as beset her.



TEST TUBE BABIES. *A History of the Artificial Impregnation of Human Beings, Including a Detailed Account of its Technique, Together with Personal Experiences, Clinical Cases, a Review of its Literature, and the Medical and Legal Aspects Involved.*

By Hermann Rohleder. The Panurge Press, New York. \$3.50. 9½ x 6½; 248; 1934. This volume gives a history of the arti-

ficial impregnation of human beings, a detailed account of its technique, together with personal experience, clinical cases, a review of its literature, and the medical and legal aspects involved." In an appendix is reprinted a letter addressed to the Royal Society in 1750—*Lucina sine Concubitu*. The volume is neither documented nor indexed. That the author is unfamiliar with recent work on the most favorable period during the monthly cycle for conception is indicated by his statement that: "It is a well-known fact that fertilization is easier during menstruation than otherwise." Possibly his record of five successful cases out of nineteen cases would have been considerably bettered had he been aware of modern investigations along this line.



FIT OR UNFIT FOR MARRIAGE.

By Th. H. Van de Velde. *Chapman and Hall, London*. 10s. 6d. net. $8\frac{1}{2}$ x $5\frac{1}{2}$; xii + 362; 1934.

The object of this book is

to explain to young people of both sexes, especially before they decide to become engaged, the importance of making up their minds regarding their own fitness as well as the fitness of their partner for the obligation of marriage. It seeks to enlighten parents and guardians as to the direction in which they should use their influence, and to give to those already married who find themselves bound to an unsuitable partner such insight into the causes of their misfortune as will enable them to obtain help in dealing with their difficulties.



FASIS BIOLOGICAS DE LA MUJER (Cartas a Paloma). *Pubertad, Noviazgo, Boda, Embarazo, Parto, Puerperio, Crianza, Aborto, Esterilidad, Complejo de Maternalidad, Procreación Consciente, Edad Crítica, Menopausia*.

By Francisco Haro. *Javier Morata, Madrid*. 5 pesetas. $7\frac{1}{2}$ x 5; 230; 1934 (paper).

In a series of letters to an imaginary young lady, Paloma, supposedly written at different periods in her life, the author gives excellent medical advice. The first letter follows the girl's menarche and in it is given the explanation of the phenomenon and the care to be taken. The other

letters regard the girl's engagement, marriage, pregnancy, delivery, abortion, and desire for family limitation. A last letter treats of menopause and its consequences. The literary form used appears to be well adapted to the subject, probably because the author is at all times a friendly physician and never a preacher.



THE TECHNIQUE OF CONTRACEPTION. *An Outline. Second Edition.*

By Eric M. Matsner. *Published for the American Birth Control League, by The Williams & Wilkins Co., Baltimore*. 50 cents. $8\frac{1}{2}$ x $5\frac{1}{2}$; 38; 1934 (paper).

The first edition of this book was reviewed in Volume 8, page 378. Dr. Matsner divides the methods of contraception which he describes into: those found to be most practical and therefore most acceptable to prescribe; those found to be impractical for general use, uncertain and questionable; those needing further experimental and developmental research before being prescribed for general use. However, he admits that the ideal contraceptive has not yet been found. There is a bibliography of one page.



AMERICAN ENCYCLOPEDIA OF SEX.

By Adolph F. Niemoeller. *The Panurge Press, New York*. \$5.00. $9\frac{1}{2}$ x $6\frac{1}{2}$; 277; 1935.

With the aid of this dictionary even the most delicately nurtured person should be able to understand pseudo-scientific literature on sex, journalistic pornography, the language of taxicab drivers, and the chalked inscriptions that appear on sidewalks and fences in the spring of the year. Only the coarser expressions in use in rural regions are omitted.



THE SAFE PERIOD or the Natural Method of Birth Control.

By William J. Robinson. *Eugenics Publishing Co., New York*. 10 cents. $7\frac{1}{2}$ x $5\frac{1}{2}$; 16; 1935 (paper).

In a sprightly style the author gives a

popular explanation of the Ogino-Knaus theory of the female "safe-period." He justly cautions that too much reliance cannot be placed on the "safe-period" and remarks in characteristic manner: "Trust in the Ogino-Knaus theory and have a prevenience jelly handy."



BIOMETRY

STATISTICAL CONFLUENCE ANALYSIS BY MEANS OF COMPLETE REGRESSION SYSTEMS.

By Ragnar Frisch. *Universitetets Økonomiske Institutt, Oslo*. 9½ x 6; 192; 1934.

In partial regression analysis there is danger of obtaining meaningless results whenever one includes in the same regression equation a set of variates containing two or more subsets which are already highly correlated. For instance, suppose that we are considering three variates between which there exist two linear equations. When observations are represented in three dimensional space all the points will lie on a straight line and, while the zero-order regression of any one of the variates on any other is perfectly determinate, the partial regression of one variate on any other is indeterminate. If the variates are subject to random errors the regression coefficients will no longer be of the indeterminate form 0/0, but will be the quotient of one random error by another. These apparently determinate regressions will therefore be meaningless. The author believes that as a result of neglect of this point "a substantial part of the regression and correlation analyses which have been made on economic data in recent years is nonsense." In this interesting book he develops methods intended to warn the statistician of this pitfall. These methods are based in part on the reduction in variation of the observed points around the regression plane as new variates are added and in part on the criterion that a regression coefficient between two given variates should change but little when based on minimization of sum square residuals in different directions. In an artificially constructed example the new technique yields conclusions agreeing with what is known *a priori* about the

manner of construction of the variates. In another example it is applied to measuring money flexibility from a six-variate analysis of annual consumption statistics from 1919 to 1931. Perhaps we are old fashioned but to us a six-variate analysis based on thirteen observations seems rather like overfitting.



COMPARABILITY OF MATERNAL MORTALITY RATES IN THE UNITED STATES AND CERTAIN FOREIGN COUNTRIES. *A Study of the Effects of Variations in Assignment Procedures, Definitions of Live Births, and Completeness of Birth Registration*. U. S. Department of Labor, Children's Bureau, Publication No. 229.

By Elizabeth C. Tandy. U. S. Government Printing Office, Washington. 5 cents. 9 x 5½; v + 24; 1935 (paper).

The high maternal mortality rates for the United States as compared with those for other countries have been often attributed to the difference in assignment procedures of cause of death. In order to obtain data on the extent of this difference 477 selected United States death certificates, on which pregnancy or childbirth were mentioned, were sent to the Vital Statistics Bureaus of 16 foreign countries with the request to classify the cause of death as puerperal or non-puerperal. Statistical analysis of the results leads the author to conclude "that differences in methods of assignment are insufficient to explain the high mortality rate of the United States as compared to foreign countries." In addition, the author finds that differences in definition of live births and the incompleteness of birth registration here are not factors of great importance "in connection with comparability."



FOREST MENSURATION.

By Donald Bruce and Francis X. Schumacher. McGraw-Hill Book Co., New York. \$3.50. 9 x 6; xiv + 360; 1935.

A textbook of mathematical technique in the collection and elaboration of quantitative data in forestry. The first part, on direct measurements, describes the instruments and methods of measuring diameter,

height, volume, and age of trees. It is introduced by a good though brief discussion on measurement in general. In the second and third parts there is an outline of elementary statistical methods, calculations of constants, measures of dispersion, the fitting of simple curves, together with numerous applications to problems in forestry. This volume lacks a comprehensive bibliography, but there is an appendix with some useful tables.



TREND ANALYSIS OF STATISTICS. *Theory and Technique.*

By Max Sasuly. *Brookings Institution, Washington.* \$5.00. 9½ x 6½; xiii + 421; 1934.

This is a treatise on the least square fitting of polynomials and on related topics, such as interpolation and fitting by moving polynomial arcs and moving averages. Extensive use is made of orthogonal polynomials and of factorial moments instead of the usual power moments. Tables of coefficients useful in fitting, bibliographic footnotes and indexes are provided.



PSYCHOLOGY AND BEHAVIOR

COMPARATIVE PSYCHOLOGY MONOGRAPHS, Vol. 11, No. 2, Serial No. 52. *Studies of Cerebral Function in Learning. XI. The Behavior of the Rat in Latch Box Situations. The Mechanism of Vision. XII. Nervous Structures Concerned in the Acquisition and Retention of Habits Based on Reactions to Light.*

By K. S. Lashley. *The Johns Hopkins Press, Baltimore.* \$1.25. 10 x 6½; 79; 1935 (paper).

Since the days of Gall and Spurzheim the problem of localization of function in the brain has puzzled psychologists. On the one hand it has been concluded that there is a high degree of specialization of certain functions; on the other hand various investigators, especially Franz and Lashley, have found evidence that the cortex functions as a whole. In the two parts of this interesting monograph Lashley deals with the retention and relearning of latch box

habits and of visual discriminations by rats after experimental extirpation of parts of the cortex. With regard to the latch box habits he concludes "that the mechanism of association, as such, is not disturbed by cerebral lesions and that retardation from cerebral lesions is due rather to disturbance of such functions as are implied by the terms attention, insight and initiative."

As to visual discrimination

So long as any small part of the geniculo-striate system remained intact perfect retention of the habit was possible. . . . With complete destruction of both striate areas and complete degeneration of the lateral geniculate nuclei, the animals required as much practice for relearning as for initial learning before the operation. The postoperative loss or the habit thus follows an all-or-nothing principle, and occurs only after complete destruction of the striate areas. Computation of correlations between extent of cerebral lesion and postoperative training records gives coefficients of about 0.60, due to the inclusion of cases with and without complete destruction of the striate areas. My earlier conclusion that the loss of the habit is proportional to the amount of tissue destroyed, irrespective of locus within the visual areas, was therefore incorrect.



STUDIES IN INFANT BEHAVIOR I. *University of Iowa Studies. Studies in Child Welfare. Volume IX, No. 4, New Series No. 281.*

By Orvis C. Irwin, LaBerta A. Weiss, and Esther M. Stubbs. *University of Iowa, Iowa City.* \$1.35 (paper); \$1.70 (cloth). 9½ x 6; 175; 1934.

BEHAVIOR OF THE PRESCHOOL CHILD. *University of Iowa Studies. Studies in Child Welfare. Volume IX, No. 3, New Series No. 275.*

By Lois M. Jack, Elizabeth M. Manwell, Ida G. Mengert, Esther Van C. Berne, Helen G. Kelly, LaBerta A. Weiss, Agnes F. Ricketts. *University of Iowa, Iowa City.* \$1.35 (paper); \$1.70 (cloth). 9½ x 6; 171; 1934.

The first of these studies comprises five wholly separate and complete investigations on the new-born infant. Part I is concerned with differential variations in the amount of activity of new-born infants under continuous light and sound stimulation; Part II deals with the effect of the factors of duration, intensity and pitch of sound stimuli on the responses of new-born infants; Part III is a study of differential

variations in the activity and crying of the new-born infant under different intensities of light; Part IV, The effect of clothing on the general and vocal activity of the new-born infant, and Part V, The effect of darkness on the activity of new-born infants. The experimental findings in each of the five studies were treated biometrically, and will provide useful data for future research on infant behavior.

Studies in the behavior of the preschool child were made on 2, 3 and 4 year old children. The first of the studies deals with an experimental study of ascendant behavior in preschool children. Ascendancy is defined as follows: "An ascendant individual is one who acts in accordance with his own desires and places himself in a position of advancement." Ascendancy was correlated with such characteristics as social responsiveness, expansive behavior, competitive attitudes, etc. Part II concerns a study of the development of two and three year old children with respect to play activities. Part III is an extremely interesting section on the adequacy of samples of behavior obtained during short observation periods; Part IV is an experimental investigation of certain factors involved in the preschool child's compliance with commands, and Part V is a study of the behavior of young children in anger.



PSYCHOLOGY AND HEALTH.

By H. Banister. *The Macmillan Co., New York.* \$2.50. 7 $\frac{1}{4}$ x 5 $\frac{1}{4}$; viii + 256; 1935.

A highly useful book for doctors, parents, teachers and social workers. The author is a lecturer in experimental psychology in the University of Cambridge. He sets forth in these pages the theories of Janet, Freud, Jung and Adler but follows no one school to the exclusion of the others; he discusses the problem child and infantile sexuality: the importance for the doctor of a knowledge of psychology and the troubles which he is called upon to face not only in the mentally diseased but in the healthy minded patient as well; treatment by suggestion, and by analysis. In the final chapter there is discussed at

length the author's views on what he terms the "sentiment formation tendency" and he concludes with the statement that "I strongly hold that everyone would be the better if he understood something of the growth of sentiments, of the formation of character, and of the dangers and ills that may accrue if, from any cause, the proper development of sentiments is impeded. The dissemination of this knowledge is, I think, one of the most important duties of the already overburdened general practitioner." The volume contains a useful bibliography and an index.



THE FUNCTIONS OF THE VISUAL AREAS OF THE CEREBRAL CORTEX OF THE RAT IN THE LEARNING AND RETENTION OF THE MAZE. I. *Comparative Psychology Monographs, Vol. 10, No. 4, Serial No. 50.*

By Yü-Chüan Tsang. *The Johns Hopkins Press, Baltimore.* \$1.00. 10 x 7; 56; 1934 (paper).

The problem as stated by the author in the opening paragraph is: "Is the function of the sensory areas of the cerebral cortex strictly sensory or imaginal, or do the areas have some additional function which is not directly related to their sensory processes but is a less specific contribution to the general efficiency of the performance."

Maze performance tests were made on 96 female rats, divided into five groups: (1) Normal controls; (2) Peripherally 'blinded', both eyes enucleated; (3) Cortically 'blinded', visual cortex destroyed, eyes intact; (4) Both peripherally and cortically blinded, both eyes and visual cortex removed; (5) A control group, partially cortically blinded.

The essential point to come out of the experiment was that destruction of the visual cortex in part or in whole is significantly more detrimental to maze performance than just peripheral blinding, that is, removal of the eyes. The author believes that the inability of the cortically operated animals to adjust themselves to the maze is due to "the mutilation of the cerebral integrative function, that is to general dementia."

HUMAN PERSONALITY AND THE ENVIRONMENT.

By Charles M. Campbell. *The Macmillan Co., New York.* \$3.00. 8½ x 5½; xi + 252 + 6 plates; 1934.

In this book, originally given as a series of Lowell lectures, a wise and understanding psychiatrist attempts "to give a more vivid and precise meaning to the word personality, and to stimulate the interest of [the reader] in the driving forces of the individual life." He deals in turn with the relation of the personality to the physico-chemical environment and to the physiological mechanisms of the organism, its development from the ovum to the adult, its dynamic systems and their integration, some of the tasks which confront it, such as the maintenance of its integrity and of equilibrium between conflicting internal tendencies, and finally "some of the ways in which the individual attempts to do justice to the needs of his own complex nature and to play his rôle in the endless drama of the universe." There are numerous bibliographic footnotes and an index.



A TEXTBOOK OF EXPERIMENTAL AND THEORETICAL PSYCHOLOGY.

By Ernest B. Skaggs. *Christopher Publishing Co., Boston.* \$4.00. 9½ x 6; 426; 1935.

A very fair, unbiased text-book on psychology written from the point of view "that all explanation of an immediate kind in psychology must be in terms of the structure and functioning of the nervous system."

One characteristic of the book which should be very helpful to the student is the author's admirable habit of stating all sides of a controversial subject, then giving his own position and explaining why he holds it.

Our chief complaint with the book is in regard to the cuts. The figures such as those of the ear and brain structure are too small and too dark to show the requisite detail.

PSYCHO-ANALYSIS FOR TEACHERS AND PARENTS. *Introductory Lectures.*

By Anna Freud. Translated by Barbara Low. *Emerson Books, New York.* \$1.75. 7½ x 4½; 117; 1935.

In this day and age when Oedipus complexes provide dinner table conversation this little book seems unnecessarily simple and elementary. But perhaps Sigmund Freud's daughter—the author—knows what an audience of teachers needs and wants in such matters. The unconscious, repression, reaction-formation, sublimation, complexes, the libido, the theory of infantile sexuality—these are all explained very simply and untechnically. There is very little of practical advice as to how to avoid the unpleasant results of misguided repressions, however.

DIE TIERPSYCHOLOGISCHE FORSCHUNG. *Ihre Ziele und Wege. Bios Band II.*

By J. A. Bierens de Haan. *Johann Ambrosius Barth, Leipzig.* 6.60 marks. 9½ x 6½; xi + 96; 1935 (paper).

The author has done an excellent piece of work in presenting, in somewhat less than 100 pages, a readable, comprehensive survey of the experimental work on animal psychology and behavior—methods and their development, aims, and results. Several times he emphasizes the need of caution in the interpretation of results, especially in two special sections on reflex action and performance, and the "consciousness" of animals. An eight-page bibliography is provided but there is no index.



DE OMNIBUS REBUS ET QUIBUSDEM ALIIS

COSMOGONIES OF OUR FATHERS. *Some Theories of the Seventeenth and the Eighteenth Centuries.*

By Katharine B. Collier. *Columbia University Press, New York.* \$5.00. 8½ x 5½; 500; 1934.

As the author of this interesting study of a curious phase in the history of science points out, when new scientific discoveries conflict with old cosmological doctrines, sanctioned by religious tradition, four types of reaction are possible. "The first type is a vigorous rejection of all new

thought that does not square with the old; the second, a discarding of all the old because of its apparent disagreement with the new; the third, a peculiar arrangement of the mind in thought-tight compartments to prevent any influence from one set of doctrines upon another; and the fourth an attempt to harmonize the new with the old thought."

This book is a history of reconciliatory gymnastics during the seventeenth and eighteenth centuries. In Roman Catholic countries the burning of Bruno and the condemnation of Galileo made authors wary of attempting to show that the newer doctrines might be harmonized with the Biblical account. In Protestant countries, on the other hand, and especially in England, the reconcilers flourished. Fludd, Burnet, Warren, Keill, Ray, Whiston, Woodward, Grew, Dickinson, Witty, Derham, Hutchinson, Swinden and Pike, among others, produced works in which the Biblical narrative and the science of the day are stretched and squeezed in various ways to fit each other. In the middle of the eighteenth century Buffon suggested that the days of creation were really epochs, each of several thousand years, a device that has retained its popularity among reconcilers to the present time. By the end of the eighteenth century, however, general opinion had come to agree with Baronius that the Bible was written to teach mankind how to go to heaven and not how the heavens go. The astronomers were left free to develop their subject in their own way. However, the biologists had later to fight for the like freedom.

The book contains a bibliography of 24 pages and an index.



A HISTORY OF MAGIC AND EXPERIMENTAL SCIENCE. Volumes III and IV. Fourteenth and Fifteenth Centuries.

By Lynn Thorndike. Columbia University Press, New York. \$10.00 per set. 8½ x 5½; Vol. 1, xxvi + 827; Vol. 2, xviii + 767; 1934.

In these two massive and carefully documented volumes Professor Thorndike carries to the beginning of modern times the history of that strange mixture of magic,

rationalism, and observation from which modern science developed. On the whole the occult predominates in the record of these, as of preceding centuries. Yet the quantitative interests of Richard Suiseth, called Calculator, Henry of Hesse, Oresme, Blasius of Parma and Nicholas of Cusa, the astronomical clocks of James and John de Dondis, the anthropological observations of Michael Savonarola, and the recognition of erosion and the gradualness of geological change by John de Fundis, are all adumbrations of the new spirit which was to accomplish such notable things in the seventeenth and later centuries. Of particular interest to a biometrician is Oresme's discussion of "latitude," as in his statement that "between maximum and minimum... there is greater latitude in one species than in another," greater in men, for example, than in hares. This seems to foreshadow the modern biometric interest in relative variability.

John de Dondis in his *De Fontibus* speaks of having been in medical attendance on "Galeacii Vicecomitis Mediolani et comitis virtutum filius praeclaræ indolis." Thorndike renders this as "the son of Galeazzo Visconti, count of Vertus." But is "virtutum" the name of a place? Is not the meaning of the passage somewhat as follows: the son of Galeazzo Visconti, of Milano, count of illustrious spirit and valor?



LE NOUVEL ESPRIT SCIENTIFIQUE.

By Gaston Bachelard. Félix Alcan, Paris.

10 francs. 7½ x 4½; 180; 1934 (paper).

According to Professor Bachelard the newer advances of science have been made, not by the refinement of older theories through a process of successive approximation, but by a critical examination of the basal postulates of the older theories. Thus Lobatchewsky, exploring the results of a denial of the postulate of parallels, was led to the development of a non-Euclidian geometry, which includes Euclidian geometry as a special case. Thus Einstein, starting from a critical examination of the supposedly primitive idea of simultaneity, arrived at a non-Newtonian mechanics, which again includes New-

tonian mechanics as a special case. Wave mechanics and the theory of quanta are further examples of the same process, which Bachelard regards as the development of a non-Cartesian epistemology. In place of the criteria of simplicity and clarity by which Descartes tested the ideas which were to serve as foundation to the edifice of the sciences Bachelard would substitute the criterion of completeness. He is moreover well aware that as the structure grows it may be necessary to take out the old corner stone and replace it with a new one. This stimulating book recalls an idea that Merz developed a number of years ago in his *History of European Thought*, that analysis and subsequent synthesis carry one only a certain distance in his quest for understanding, that they need to be supplemented by a synoptic method which regards phenomena in their relations with other phenomena.



GRAVITATION, SPACE-TIME AND MATTER.

A Study of the Relation of Gravitation to the Flow of Time; the Atomic Organization of Space-Time; the 126 Isotopoids of Hydrogen; and the Photonic Nature of the Atoms.

By Albert P. Mathews. Albert P. Mathews, University of Cincinnati. $9\frac{1}{2} \times 6\frac{1}{2}$; 103; 1934 (paper).

The author has attempted here to build upon the more recent discoveries in theoretical physics a new philosophical system. The results of his discussion can be summarized as follows:

Light = Matter = Electricity = Ether = Space-time = Life.

Everything is constituted of Life, another name for reality. For it is Life which appears in these various external guises of activity and passivity; of becoming and being; and which appears also in the internal guise of mind.

There are obviously two kinds of space-time; two kinds of Life: Material and immaterial; created and uncreated; mortal and immortal.

The whole of space-time, both material and immaterial, created and uncreated, in its objective aspect of activity, i.e., its aspect of discontinuity, has an atomic structure. It presents itself to us as an immense swarm of Living Units or organisms. These are the di-poles; the created and uncreated hydrogen atoms; the created and uncreated photons. For if the material be considered to be granular, as it must be considered in its activity aspects, then the immaterial or uncreated must also be so considered. If we

are living individuals, the immaterial must also be constituted of immaterial living individuals.



LIONS STARVE IN NAPLES.

By Johan Fabricius. Translated from the German by Phyllis and Trevor Blewitt. Little, Brown and Co., Boston. \$2.00. $7\frac{1}{2} \times 5$; 311; 1935.

This tale of the spiritual and material development of that talented young Neapolitan lawyer Ramboldo Fittipaldi, as Storm's Circus got deeper and deeper into difficulties because of the depression and a terribly cold winter, is delightful. No biologist could possibly resist its charm—nor, for that matter, anybody else so far as we can see. Its relation to biology is indirect; perhaps a pedant might even say remote. But this is really not so. To the human biologist it is a superb document. It gives such a picture of Neapolitan character as has never been put on paper before. Our advice to all and sundry is to buy, beg, borrow or steal it at once, and settle down to some hours of unadulterated enjoyment.



DICTIONARY OF FOREIGN TERMS Found in English and American Writings of Yesterday and Today.

By C. O. Sylvester Mawson. Thomas Y. Crowell Co., New York. \$2.00. $7\frac{1}{2} \times 5$; x + 389; 1934.

This extremely useful dictionary contains a variety of foreign expressions which one finds more or less frequently in literature, periodicals and the daily press. Included in the contents are (1) foreign words and phrases from more than fifty languages, (2) proverbs, (3) mottoes, (4) quotations, (5) French and Spanish Americanisms, (6) Orientalisms, (7) naval and military terms, (8) menu terms, (9) translations or definitions of all foreign terms, (10) plurals, (11) feminines of foreign nouns and adjectives, and (12) foreign abbreviations.



METAMORPHOSES.

Drawings left by Dr. Marianne van Herwerden. Job. Enschedé en Zonen, Haarlem. 2.25 guilders. $8\frac{1}{2} \times 5\frac{1}{2}$; 76; 1934.

While we had known and admired for many years the late Dr. Marianne van Herwerden, we were not aware of her talents as an imaginative artist and humorist until this charming little posthumous volume came to hand. The introduction explains its provenance.



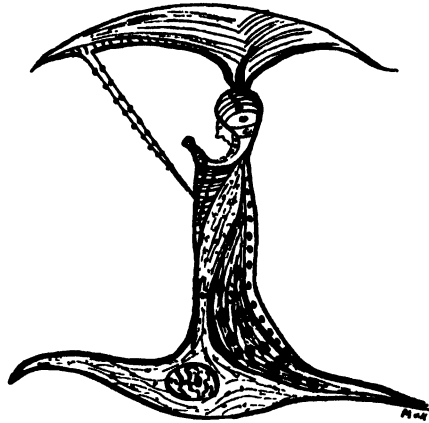
Fig. 161. Querschnitt einer Schneckenwindung vom Meer
schwammchen.
TOLDT, C. *Lehrbuch der Geologie* (1888)

Dr. Marianne van Herwerden, a well-known Cytologist and Geneticist has left a number of drawings, some of which are published in this booklet.

It was only in the later years of her life that she took up this playing with lines and forms. As a rule she made these drawings late in the evening after a day of strenuous brain work. Then she gave her sense of humour and exquisite wit free scope and then the figures out of scientific works reappeared in a new shape. In making these drawings no publication was aimed at. Even by careful research it has

not been possible to identify all of the drawings; so some of them have been taken up without any corresponding scientific figure.

Limitations of space and technique prevent the presentation here of adequate examples of the delightfully fantastic bits of wit that fill the book. Many



of the drawings are in color. However, we do like the one here reproduced that falls within our limitations.

All biologists owe a debt of gratitude to Dr. Marie Löhnis for collecting the drawings and seeing through the press this charming memorial of a distinguished cytologist and geneticist.

THE QUARTERLY REVIEW of BIOLOGY



SOME HISTORICAL ASPECTS OF THE RECAPITULATION IDEA

By A. W. MEYER

Department of Anatomy, Stanford University

IT IS well to remember in connection with the theory of recapitulation that scientific, like other dogmas, undergo modification in the course of time. It hence seems best to speak of ideas, hypotheses, theories or doctrines rather than merely of a theory, or perchance of a law of recapitulation. Varying aspects of what we call recapitulation attracted attention at different times and appealed to or were espoused by various writers and investigators.

I have not as yet been able to learn who first used the word recapitulation in a biological sense or spoke of a recapitulation theory, but according to the *Oxford Dictionary*, the word recapitulation was used by Dyer, writing in the *Encyclopædia Britannica* III, 692/2, in 1875. In this Dictionary Lankester also is quoted (Degener, '21) as having declared in 1879 that: "Suppose . . . that the Barnacles . . . instead of recapitulating in their early life, were to develop directly from the egg to the adult form." I do not know whether the idea that a developing organism loiters along the way originated with Lankester or whether it had been entertained by others,

but such a conception of recapitulation implies that much time is wasted especially by higher organisms through deviations during their ontogeny.

ARISTOTLE

In regard to recapitulation as in regard to many other matters biological, it is necessary to begin with "the master of them that know." Although I do not feel that anything Aristotle wrote necessitates this, there are those who hold a different view. Needham, for example, when referring to Aristotle's ideas of "the degree of aliveness" in embryos stated that (p. 64): "Aristotle does not here anticipate the form of the recapitulation theory, but he certainly suggests the essence of it in perfectly clear terms." Needham further stated that (pp. 69-70):

Aristotle has a good deal to say about the theory of recapitulation, as it was afterwards to be called. He thought there was no doubt that the vegetative or nutritive soul existed in the unfertilised material of the embryo, "for nobody," as he says, "would put down the unfertilised embryo as soulless or in every sense bereft of life, (since both the semen and the embryo of an animal have every bit as much life as a plant) and it is productive up to a certain point. . . .

As it develops it also acquires the sensitive soul in virtue of which an animal is an animal. . . . For first of all such embryos seem to live the life of a plant, and it is clear that we must be guided by this in speaking of the sensitive and the rational soul. For all three kinds of soul, not only the nutritive, must be possessed potentially before they are possessed actually."

According to Needham,

These passages show very clearly the line of thought contained in the recapitulation theory, as do the following. "For an animal does not become at the same time an animal and a man or a horse or any other particular animal," i.e. the more general appears first and the more particular later. "For the end is developed last, and the peculiar character of the species is the end of the generation in each individual," i.e. the embryo attains the point of being definitely not a plant before it attains that of being not a mollusc but a horse or a man. Aristotle concludes that the different sorts of souls enter the embryo at different stages of development, just as the shape of the embryo gradually approximates to whatever adult shape it is destined to conform to.

Needham held that (p. 75) Aristotle also "... foreshadowed the theory of recapitulation in his speculations on the order in which the souls came to inhabit the embryo during its growth, and in his observation that universal characteristics precede particular characteristics in embryogeny."

Meckel also spoke of Aristotle in connection with recapitulation, and referred to the following words (*De Generat. Animal.*, Book II, 3, c. 9): "For e.g. an animal does not become at the same time an animal and a man or a horse or any other particular animal. For the end is developed last, and the peculiar character of the species is the end of the generation in each individual." I acknowledge that whether or not the words quoted by Needham and referred to by Meckel justify us in regarding Aristotle as the source of the idea of recapitulation is a matter of opinion, but I do not feel that they do so, for even if Aristotle dissected fifty different kinds of

animals and knew some embryonic forms, neither comparative anatomy nor embryology had developed sufficiently to afford an adequate basis for such a generalization as that of recapitulation.

HARVEY

According to Needham, the idea of recapitulation is contained also in the following words of Harvey (p. 141): "'About the fourth day the egg beginneth to step from the life of a plant to that of an animal.' 'From that to the tenth it enjoys a sensitive and moving soul as Animals do, and after that, it is compleated by degrees and being adorned with Plumes, Bill, Clawes and other furniture, it hastens to get out.'" Needham added, however, that "These and other passages which deal with the forerunner of the theory of recapitulation, are interesting, but we have already met essentially the same idea in Aristotle."

Since Meckel also referred to Harvey, it is well to examine everything from him that seems at all pertinent to the subject. In *De Generat. Exercit.*, p. 165, we read:

... for all animals resemble one or other of those above mentioned [fowl, goose, duck, pigeon; frog, serpent, fish; crustacea, testacea, silkworms; sheep, goats, dogs, cats, deer, oxen; man], and agree with them either generally or specifically, and are procreated in the same manner, or the mode of their generation at least is referrible by analogy to that of one or other of them. For Nature, perfect and divine, is ever in the same things harmonious with herself, and as her works either agree or differ, (viz. in genus, species, or some other proportion), so is her agency in these (viz. generation or development) either the same or diverse.

De Generat. Exercit. p. 163: For example, before a man attains to maturity, he was a body, an infant, an embryo. And then it is indispensable to inquire further as to what he was in his mother's womb before he was an embryo or foetus. . . .

In *De Motu Cordis* (Leake transl. 1931), p. 127,¹ Harvey declared:

Thus divine Nature making nothing in vain, neither gives a heart to an animal where it is not needed, nor makes one before it can be used. By the same steps in the development of every animal, passing through the structural stages, I might say, of egg, worm, and fetus, it obtains perfection in each. These points are confirmed elsewhere by many observations on the formation of the fetus.

In his very interesting and instructive volume on *Early Theories of Sex Generation*, Cole also says that Harvey, in *De Motu Cordis*, has a passage which foreshadows the recapitulation doctrine in embryology, based on numerous observations of the formation of the fetus. I have already quoted the sentence from Harvey to which Cole seems to refer, and to which Meckel also referred. It is possible that Cole had a different sentence in mind and that his conclusion may hence be justified, but I have not been able to find a more pertinent passage in Harvey than the one quoted above. It is possible that Harvey had recapitulation in mind when he suggested that every animal passes through the stage of egg, worm and fetus but the general tenor of Harvey's *De Generatione* and the undeveloped state of embryology and comparative anatomy and the dormant condition of the evolution concept, scarcely justify one in concluding that he was so far in advance of his day in regard to this idea.

JOHN HUNTER

There is no doubt regarding John Hunter, however, for he expressed himself adequately even if not very clearly or fully. I do not know the exact date of the formulation of this idea in Hunter's mind, but I believe that Owen was wholly justified in speaking of "the following remarkable one [passage] from Hunter's description of his drawings illustrative of the development of the chick" of the goose. Since Hunter apparently worked on the chick as early as 1755, this passage

may have been formulated about that time. It is found in the *Progress and Peculiarities of the Chick* and reads as follows (*Essays and Observations*, p. 203):

If we were capable of following the progress of increase of the number of the parts of the most perfect animal, as they first formed in succession from the very first to its state of full perfection, we should probably be able to compare it with some one of the incomplete animals themselves, of every order of animals in the Creation, being at no stage different from some of the inferior orders. Or, in other words, if we were to take a series of animals, from the more imperfect to the perfect, we should probably find an imperfect animal, corresponding with some stage of the most perfect.

In commenting upon Hunter's words in the preface to *Observations on Certain Parts of the Animal Economy*, Owen wrote (p. 26): "We may, I think, perceive, from the evident difficulty with which Hunter expresses the idea, that his mind was oppressed with both its novelty and vastness. Men's thoughts require to be familiarized with propositions of such generality before their exact limits and full application can be appreciated." Be this as it may, it is well known that John Hunter was quite unfamiliar with the literature of the subjects with which he dealt and lacked the power of clear expression possessed by his brother William. Although Owen thought his expression rather labored, and Russell (1916) called it confused, it seems to me that it undoubtedly is a statement of the idea of recapitulation. Hunter was a man of new ideas and a comparative anatomist of very wide experience. However, since new ideas have a way of spreading independently of books, it is possible that knowledge of some version of recapitulation held by some predecessor of his may have reached him, but that is purely a matter of conjecture. Hunter's formulation of recapitulation probably remained unknown at the time because he was careless about

publication. The illustrations that accompany his study of the development of the chick have not, as far as I know, been reproduced in their entirety even to this day, and although Sedgwick in the eleventh edition of the *Britannica*, Russell in his *Form and Function*, and Garrison in his *History of Medicine*, called attention to Hunter's formulation of the theory of recapitulation, it undoubtedly will be some time before his merits will become more generally known. It is interesting that Rádl in his splendid work on the history of biological theories does not mention John Hunter.

KIELMEYER

In *Evolution and Adaptation* (p. 58), Morgan stated that Kiemeyer (1793) was the first to suggest the idea of recapitulation, and Meckel likewise mentioned Kiemeyer first. In his *Rede ueber die Verhältnisse der organischen Kräfte unter einander in der Reihe der verschiedenen Organisationen, die Gesetze und Folgen dieser Verhältnisse*, Kiemeyer reverted to the idea of Aristotle that the human embryo at first has a purely vegetative life like a plant, then that of lower animals which move but do not feel, and finally reaches the stage of both motion and feeling. Carus, when speaking of Kiemeyer in his *Geschichte der Zoologie*, declared (p. 583):

"Dass der Embryo höherer Thiere die Formen-zustände niederer Classen durchlaufe, hatte schon 1793 Kiemeyer ausgesprochen, dies war also nicht Oken's Verdienst. Uebrigens hat die Idee nur dann wirklich Anregendes, wenn sie bei entwicklungsgeschichtlichen Betrachtungen innerhalb der einzelnen Typen beachtet wird; ausserdem verleitet sie zu vagen Spielereien mit Analogien. . . ." (p. 593)
 "Bei seinen Ableitungen kommt er auch aus den Vergleich früherer Entwicklungszustände höherer Thiere mit niederen Thieren. Da ihm aber Entwicklungsgeschichte noch fern lag, gelingt es ihm nicht, diesen Satz fruchtbar zu verwenden."

This expression of recapitulation is no more definite than that made by John Hunter considerably earlier. However, that Kiemeyer considered the idea at length is evidenced by a public lecture and the publications of his students. Hunter confined himself to a brief expression.

When discussing recapitulation in his treatise on comparative anatomy, Meckel mentioned Kiemeyer first but also referred to Autenrieth (1797), Carlisle (1805), Oken (1806), Walther (1807-1808), Blumenbach (1813), Tiedemann (1819), Carus (1814 and 1818), de Blainville (1819), and himself (1806 and 1811). As far as I have been able to ascertain, none of these men except Oken made as significant an expression as John Hunter. Carlisle merely wrote (p. 5): "The punctum saliens, during its first action, is not encompassed by any fibers discoverable with microscopes, and the vascular system is not then evolved, the blood flowing forwards, and backwards, in the same vessels. The commencement of life in animals of complex structures is, from the preceding fact, like the ultimate organization of the simpler classes." The frequency with which the latter idea is mentioned by various writers suggests that it was entertained rather generally. Hertwig (1906) also mentioned Kiemeyer, Oken, Tiedemann, Carus and de Blainville but merely said that they noticed similarity in form between prenatal stages of higher and mature forms of lower animals.

Rádl called Kiemeyer an unintentional mediator between the dynamic and morphological tendencies of his time. He said he tried to explain all resemblances and differences between organisms through the effect of manifold vital "forces" such as sensibility, irritability, reproduction, secretion and propulsion and attempted to explain how all organisms, including

man, have a vegetative life at first but acquire sensibility and irritability in increasing perfection until they reach their final goal. Rádl further said that Kiemeyer tried to arrange all animals in a graded series upon this basis but that he did not get beyond generalizations. It seems that Kiemeyer held that man had passed through such a scale in the course of his development and that the geological appearance of animals agrees with the progressive series of existing animals. He apparently thought that as one passed from the higher to the lower "organizations," one sense after another dropped out, the sense of touch being the last to disappear.

Kiemeyer's address of 1793 remained difficult of access until its republication by Balss (1930). The perusal of it confirms Rádl's statement that Kiemeyer belonged to the German *Naturphilosophen*, although Kiemeyer himself in a letter to Cuvier, largely rejected their ideas. Balss held that although others, including Cuvier, a pupil of Kiemeyer's, agreed with Rádl, and some of his commentators even went so far as to call Kiemeyer the father of nature philosophy, this was due to a superficial resemblance only, and to the fact that only the above address was known to them. It seems that although Kiemeyer had partly prepared a work for publication, he withdrew it and hence the only other publication by him is an address given before a scientific society at Stuttgart in 1834.

Balss and especially Buttersack, regarded Kiemeyer as something of a genius, an estimate contained also in an inscription upon a gold medal presented to him by a scientific academy, which reads:

Graius Aristoteles, Harveus Britannis,
Teutonum populis Kiemeyerus crit.

According to Balss, Kiemeyer's opinions really were based upon an extremely wide and thorough knowledge of comparative anatomy and embryology, which placed him in marked contrast to the German *Naturphilosophen*. However, Balss admitted that the address of 1793 gave one a wrong impression and called attention to theses done under Kiemeyer quoting from a volume by Münter (1840) which, it is generally recognized, was based largely if not wholly upon notes taken from Kiemeyer's lectures. Pertinent passages from this work are the following (after Balss, pp. 277-78):

So kann man sagen, ist der Mensch anfangs fisch- und froschähnlich; er nähert sich dann mehr der Form der Cetaceen und wird endlich der Form der eigentlichen Landsäugetiere genähert. . . . Jeder organische Körper stellt mit seiner Entwicklung die Reihe der bleibenden und unter ihm stehenden Organismen auf unserer Erde dar. So z. B. stellt der Embryo einer Bohne einen Fucus in seiner bleibenden Gestalt dar; ebenso ist es der Fall mit den Fröschen, die anfangs den Fischen gleichen, dann bei weiterer Entwicklung die Form der Salamander bekommen und erst späterhin die Förschform annehmen. Kurz, der organische Körper durchgeht während seiner Entwicklung die permanente Reihe der Organismen, und umgekehrt muss man die permanente Reihe der organischen Körper an der Entwicklungsgeschichte des einzelnen Organismus studieren (S. 261).

The passages in Kiemeyer's address of 1793 which bear upon this point are the following (pp. 261-62):

Somit wäre also nun nach sehr einfachen Gesetzen dieses Verhältniss in der Reihe der Thiere abgeändert; die Simplicität dieser Gesetze, die sich in eine so ungeheure Mannigfaltigkeit ergiessen, muss aber noch mehr auffallen, wenn man bedenkt, dass eben diese Gesetze, nach welchen die Kräfte an die verschiedene Organisationen vertheilt sind, gerade auch die sind, nach denen die Vertheilung der Kräfte an die verschiedene Individuen der nehmlichen Gattung, ja auch an ein und dasselbe Individuum in seinen verschiedenen Entwicklungsperioden geschah: auch der Mensch und Vogel sind in ihrem ersten Zustande pflanzenartig, rege ist die Reproductionskraft in

ihnen, späterhin hebt sich in dem feuchten Elemente, in dem sie dann leben, ihre Irritabilität, auch das Herz dieser Thiere ist unzerstörlich reizbar, und erst späterhin schliesst sich ein Sinn nach dem andern beinahe in eben der Ordnung, wie sie in der Reihe der Organisationen von unten auf zum Vorschein kommen, in ihm auf, und was zuvor Irritabilität war, entwickelt sich am Ende zur Vorstellungsfähigkeit, oder wenigstens ihrem unsichtbaren unmittelbarsten materiellen Organ. . . .

Ja, da die Vertheilung der Kräfte in der Reihe der Organisationen dieselbe Ordnung befolgt, wie die Vertheilung in den verschiedenen Entwicklungszuständen des nehmlichen Individuums, so kann gefolgert werden, dass die Kraft durch die bei letztern die Hervorbringung geschieht, nehmlich die Reproduktionskraft in ihren Gesetzen mit der Kraft übereinstimme, durch die die Reihe der verschiedenen Organisationen der Erde ins Daseyn gerufen wurde, und da gerade nun auch die niedersten Klassen, bei denen die Individuen so zahlreich sind, in Gattungen am zahlreichsten hervorgebracht sind, so ist es noch mehr gestattet anzunehmen, dass die Kraft, durch die die Reihe der Gattungen hervorgebracht wurde, ihrer Natur und Gesetzen nach mit der, durch die die verschiedene Entwicklungszustände bewirkt wurden, wohl einerlei sei, und wirklich liesse sich auch, wenn hier der Ort wäre, diese Idee auszuführen, zeigen, dass man durch vorsichtig aufgesuchte Analogien dahin geleitet wird, eine solche materielle Ursache zur Erklärung der Entwicklungserscheinungen anzunehmen, die man sich auch bei der ersten Hervorbringung der Organisationen auf unserer Erde wirkend vorstellen kann.

MECKEL

In his *Die Zeugung* (1805) and in his *Lehrbuch der Naturphilosophie* (1810-11), Oken says that the human embryo passes through all those stages through which other animals pass, a worm, a crustacean an insect, and so forth, in turn. This idea was elaborated somewhat by Tiedemann and was also given partial expression by Swammerdam, but a fuller discussion of it with evidence for and against it, we owe to Meckel (1811 and 1821). Meckel tried to establish proof of the idea that the developmental stages of higher animals represent the final stages of the lower, by extensive gross comparative anatomical and developmental studies. He also tried

to homologize the form and function of individual organs of decidedly different groups. Had the idea of evolution gained wider adherence or more impetus, Meckel probably would have emphasized the idea of descent for he believed that development in the individual and in the group is controlled by the same forces. Meckel wrote (1821, p. 396):

Dass der Embryo höherer Thiere, ehe er seine vollkommene Ausbildung erreicht, mehrere Stufen durchläuft, wurde schon oben bemerkt; hier ist nachzuweisen, dass diese verschiedenen Stufen denen entsprechen, auf welchen tiefer stehende Thiere das ganze Leben hindurch gehemmt erschienen. In der That kommt der Embryo höherer Thiere, namentlich der Säugthiere und besonders des Menschen, durch äussere Gestalt, einzelner Organe sowohl als des ganzen Körpers, Zahl, Lage, verhältnissmässige Grösse der Organe, Gewebe, Mischung und Kräfte mit unter ihm stehenden Thieren mehr oder weniger vollkommen überein.

(p. 409) Gegen diese, schon von Aristoteles, in neuerer Zeit von Harvey angedeutete, vorzüglich jetzt von mehreren Physiologen, namentlich Kiemeier, Autenrieth, Carlisle, Oken, Walthier, dem nie alternden Blumenbach, Tiedemann, Carus, Blainville und mir ihrem hohen Werthe gemäss geachtete Gleichung zwischen der Entwicklung des Embryo und der Thierreihe haben sich mehrere Schriftsteller aus verschiedenen Gründen erklärt, welche hier zu untersuchen sind, sofern, im Fall daraus sich wirklich die Unrichtigkeit jener Ansicht ergäbe, das Gesetz der Identität einen bedeutenden Theil seiner Gültigkeit verlieren würde.

(p. 411) Ob der menschliche Embryo alle oder nur einige Bildungsstufen durchläuft, ist für diese Ansicht völlig gleichgültig, sobald sich nur aus sichern Thatsachen ergibt, dass er deren mehrere, und dass er sie immer durchläuft, dass also jene Aehnlichkeiten nicht zufällig sind. . . .

Although it is true, as von Baer said, that Meckel recognized that not all stages of the lower are repeated in the development of the higher individual and although he especially considered exceptions, he nevertheless carried the idea of parallelisms to surprising lengths. He correlated various portions and organs of the same individual such as the upper and

lower halves of the body, and extended the idea to organization and function.

Since Serres, the discoverer of Meckel's cartilage and a disciple of Saint-Hilaire, elaborated very much the same idea as did Meckel, he often is mentioned with him and the ideas they sponsored are sometimes spoken of as the "law of Meckel and Serres." This was an advance beyond the idea of parallelisms of Hunter in that it included organs and contained more of the implication of ancestry and because Meckel also considered function and abnormal development in the same light. Meckel's conclusion that abnormalities often represent arrests of development (Hemmungen) probably had its origin in his idea that lower organisms themselves represent instances of arrest of development.

CARUS

Carus, (1814) whom Meckel also mentioned, wrote as follows (p. 2):

... —Man erkannte, wie die ganze organische Welt nur die stufenweis erfolgende Entwicklung eines unendlichen Organismus darstelle, wie auf gleiche Weise die Entwicklungsgeschichte des thierischen Organismus in der unendlichen Menge verschiedener Thiergeschlechter sich fixire, wie der menschliche Organismus die endliche Vollendung dieser Entwicklung darstelle und wie er in den verschiedenen Perioden seiner Bildung, der Idee nach, die verschiedenen Entwicklungsstufen der Thierwelt wieder durchlaufe.

Carus (p. 123) expressed doubt whether a natural system of classification could reveal the embryology of organisms but added that if it did his conceptions would not be controverted. In the 1834 edition of the *Lehrbuch der vergleichenden Zoösomis*, he expressed himself as follows:

In wiefern nun die riedereren Organismen eine sehr kurze Reihe von Verwandlungen die höheren Organismen hingegen eine sehr lange Reihe derselben zu durchlaufen haben, so muss ein gewisser Parallelismus zwischen der verschiedenartigen Bildung der erstern

hervortreten. Dieser Parallelismus ist es welcher verursacht dass die einzelnen Entwicklungsstufen eines höheren Organismus stets an eine bestimmte Art der tieferen Bildungen, nicht sowohl als ein diesen Vollkommenen homogens sich anschliessen, sondern an das Wesentliche derselben erinnern.

In commenting upon this statement Carus said that this is why in the earliest stages of development, man has white blood only, as is the case in mollusks, and that like these he has no skeleton at that time.

VON BAER

I do not know who was originally or primarily responsible for the spread of the idea that von Baer formulated the "law" of recapitulation or for the fact that various writers regard von Baer's "law" and the theory of recapitulation as synonymous. According to the *Oxford Dictionary* Salesby, 1903, writing in *Academy* declared, "von Baer's law may be stated thus: Ontogeny is the recapitulation of phylogeny." Even prominent biologists are confused regarding this matter. Kellogg, for example, wrote in 1924: "This recapitulation theory is one of the greatest generalizations that has been made in biological study. It was first formulated by Karl von Baer and later made more specific—too specific, indeed—by Haeckel...." Wilson, while discussing recapitulation in a lecture at Woods Holl in 1894, referred to "a leading English biologist," who declared during that year "that von Baer's law falls to the ground." These words seem to imply that either the English biologist to whom Wilson referred, or the latter himself, or possibly both, also regarded the theory of recapitulation and von Baer's "law" as identical. Similar confusion is found in the words of Woodruff (1923) that von Baer's "emphasis on the resemblance of certain embryonic stages of higher animals to adult stages of lower forms were crystallized by his suc-

cessors, under the influence of the evolution theory as the germ layer theory and the recapitulation theory."

Although Needham had attributed the origin of the theory to Aristotle and Harvey he nevertheless spoke of "... the recapitulation theory, which was first clearly formulated by von Baer . . .," and repeated this statement several times. On page 1629, under the caption, "The Theory of Recapitulation," Needham summarized as follows:

The idea originated in the early years of the nineteenth century with Meckel; Serres; the elder Agassiz and von Baer. In those days the statement made was simply that the embryos of all species were more alike than the adults, and that the younger you took the embryos the more alike they were, so that after the advent of the cell theory, it was affirmed that when you got back to the zygote, the egg-cells of dog and duck were morphologically indistinguishable. Or as Aristotle had said, the more general characters appeared as a rule in ontogeny before the more specific ones. The following passage from von Baer, already well known, became still more famous by being quoted by Darwin in the *Origin of Species*: "The embryos of mammals, of birds, lizards, and snakes, probably also of chelonians, are in their earliest states exceedingly like one another, both as a whole, and in the mode of development of their parts; so much so, in fact, that we can often only distinguish the embryos by their size. In my possession are two little embryos in spirit, whose names I have omitted to attach, and at present I am quite unable to say to what class they belong. They may be lizards or small birds, or very young mammals, so complete is the similarity in the mode of formation of the head and trunk in these animals. The extremities, however, are still absent in these embryos. But even if they had existed in the earliest stage of their development, we should learn nothing, for the feet of lizards and mammals, the wings and feet of birds, no less than the hands and feet of man, all arise from the same fundamental form." This statement of the case was fully accepted by Darwin himself and by all the exponents of evolution. "Community in embryonic structure," he said "reveals community in descent." This was not affected by cases where the relation did not hold, dissimilarity of development did not prove discommunity of descent, because developmental stages might be missed out or so modified by the requirements of embryonic life as

not to be recognisable. This process was called 'caenogenetic modification' by Haeckel.

Morgan (1903) and Montgomery (1906) correctly stated that von Baer opposed the idea of recapitulation and Sewertzoff (1928) says he opposed that of Meckel-Serres and of Müller-Haeckel as well. That von Baer cannot rightly be regarded as the author of the theory of recapitulation is shown clearly by his own words (p. 220):

Dadurch ist aber noch nicht erwiesen, dass jeder Embryo einer höhern Thierform allmählich die niedern Thierformen durchlaufe. Vielmehr scheint sich der Typus jedes Thiers gleich anfangs im Embryo zu fixiren und die ganze Entwicklung zu beherrschen. . . . *Der Embryo des Wirbeltiers ist schon anfangs ein Wirbeltier. . . . Mithin durchlaufen die Embryonen der Wirbeltiere in ihrer Entwicklung gar keine (bekannten) bleibenden Thierformen.*

(p. 222) Diese Bemerkungen führen uns auf die Frage, ob wir denn nicht immer weiter zurückgehend auf eine Stufe gelangen können, wo auch die Embryonen der Wirbelthiere und der Wirbellosen übereinstimmen. Ich werde in einem spätern Zusatze, wo besonders von der Verschiedenheit des Bildungsschema für die Haupttypen der Thiere gesprochen wird, zu erweisen suchen, dass auch die gegliederte Thierreihe mit einem Primitivstreifen ihre Entwicklung beginnt. In diesem kurzen Momente würde also Uebereinstimmung zwischen ihnen und den Wirbelthieren seyn. In dem eigentlichen Keimzustande ist aber wahrscheinlich Uebereinstimmung unter allen Embryonen, die aus einem wahren Eie sich entwickeln. Hierin liegt ein wesentlicher Grund, den Keim für das Thier selbst anzusehen (Schol. II.) Wenn im Keime des Vogels der Primitivstreifen sich bildet, so sind wir zwar geneigt zu sagen: jetzt fängt der Embryo an.

(p. 224) Hiermit Stimmt es ganz, dass die Blasenform die allgemeine Urform ist; denn was wäre allen Thieren mehr gemeinsam, als der Gegensatz einer innern und äussern Fläche?

2) *Aus dem Allgemeinen der Formverhältnisse bildet sich das weniger Allgemeine und so fort, bis endlich das Speciellste auftritt.*

In Scholion V as given in volume I, page 199, of von Baer's *Entwicklungsgeschichte*, he wrote: "Ueber das Verhältniss der Formen, die das Individuum in

den verschiedenen Stufen seiner Entwicklung annimmt." Von Baer says that he is giving special consideration to the doctrine of recapitulation because of its importance and because the question had recently received much attention. Since the first volume of von Baer's work was published in 1828, these words must hence antedate that year.

Von Baer said further that this idea became current or active, literally alive (*lebendig*) at a time when no connected investigations on early development were known except those of Malpighi and Wolff, and that the idea was "vorzüglich durchgeführt," by a man who probably possessed the largest knowledge concerning development of higher organisms, and that this could not help but gain many adherents for it. He added that the theory in all its implications, was not accepted unreservedly by the more thoughtful individuals and especially not by him whose name had gained it most acceptance. He unfortunately did not mention his person by name, but it is very probable that he was referring to Meckel. This was also the opinion of Hertwig (1906) who, when quoting the above words from von Baer, inserted Meckel's name in the proper place.

The conclusion which I have reached regarding von Baer was reached also by Keibel who, after stating the view of Meckel on recapitulation, declared (p. 724): "Ganz anders sieht Baer die Dinge an. In bewusstem Gegensatze zur Lehre Meckels, welche man als die herrschende Lehre jener Tage ansehen darf, sagt er: 'Die individuelle Entwicklung der höheren Tierformen durchläuft nicht die ausgebildeten Formen niederer Tiere.' "

Von Baer spoke of the idea of recapitulation current in his day as follows (p. 199):

Wenige Darstellungen von Verhältnissen in der organischen Welt haben so viel Beifall gefunden, als die:

dass die höheren Tierformen in den einzelnen Stufen der Entwicklung des Individuums vom ersten Entstehen an bis zur erlangten Ausbildung den bleibenden Formen in der Thierreihe entsprechen, und dass die Entwicklung der einzelnen Thiere nach denselben Gesetzen, wie die der ganzen Thierreihe, erfolge, das höher organisirte Thier also in seiner individuellen Ausbildung dem Wesentlichen nach die unter ihm stehenden, bleibenden Stufen durchläuft, so dass die periodischen Verschiedenheiten des Individuums sich auf die Verschiedenheiten der bleibenden Tierformen zurückführen lassen. (*The original is in italics.*)

This statement by von Baer certainly shows that the idea of recapitulation current in his day included the idea of descent; that ontogeny repeats phylogeny.

Von Baer says that doubts arose in his own mind regarding the theory because he did not find that the differences among living animals would permit one to arrange them in one progressive series as should be possible if the development of the individual is to be regarded as repeating that of the series. He then raised a number of objections to it under the heading "Zweifel und Einwürfe" and declared that one cannot hold that an embryo retraces an entire "Thierreihe" because it does not pass from one type of form into the other. He concluded further that the development of an individual organ is determined by two circumstances; one, a progressive differentiation, "Ausbildung," of the animal body, and two, a "Fortbildung," or progression from a more generalized into a more specialized form, and then emphasized that the embryos of higher forms were not like the adult, but more like the embryonic forms of lower animals. These ideas often have been spoken of as the law of divergence and of embryonic resemblance.

In an important contribution upon the relation of ontogeny to phylogeny Sewertzoff (1928, p. 152) summarizes von Baer's ideas as follows:

... the order of appearance of the features characteristic of a mature animal during its ontogeny corresponds with the order of appearance of these features in the phylogeny of its ancestors. . . . The law of von Baer shows us in what order the characters present in a recent mature animal appeared in its ancestors; the law of recapitulation, on the contrary, shows the order of appearance of the features which once characterized the mature progenitors, but which are replaced by others in recent forms. . . . We see that both laws are important for the investigation of phylogeny: the one (recapitulation) enables us to reconstruct the nature (Bau) and the order of appearance of those ancestral characters which have not survived in recent forms; the other (law of von Baer) enables us to determine the order of appearance of those characters which have survived in recent forms. (Author's translation.)

As Minot well said, "Von Baer, the creator of modern scientific embryology, called attention in 1828 to the limitations which must necessarily be put upon Meckel's generalization. It is to be regretted that von Baer's wise thought on this subject has not been more appreciated." (p.30)

Since as Bacon said truth is more likely to arise from error than from confusion, it is well to add that when von Baer stated that the embryos of higher animals passed through embryonic stages of the lower and that the general characters peculiar to the large groups appeared first and the more restricted later on in ontogeny, he was, to be sure, expressing an idea of recapitulation. To this extent then von Baer and his admirer Johannes Müller, also were recapitulationists. However, since von Baer expressed himself very clearly, there is no justification for saying that the theory of recapitulation was formulated by him, for he very clearly rejected the theory as formulated before his time and made no claim to authorship of another.

Hertwig (1906) correctly summarized the views of von Baer as follows (p. 43):

Endlich haben wir noch näher auf die Stellung einzugehen, welche BAER gegenüber der Lehre

vom Parallelismus zwischen der individuellen Metamorphose und der Metamorphose des Tierreichs einnimmt. Er hält die namentlich von MECKEL ausgebildete Ansicht, dass der Embryo höherer Tiere die bleibenden Formen der niederen Tiere, durchlaufe, für nicht berechtigt und sucht dagegen den Parallelismus in folgender Weise zu erklären; Den Erklärungsgrund findet er darin, dass sich jedes Tier durch Umwandlung aus einer allgemeinen in eine sich immer mehr spezifisierende besondere Form entwickelt. "Daher ist es notwendig, dass wir in der einen wirklich historisch begründeten Folge und in der anderen genetisch gedachten Reihe eine Uebereinstimmung der in dieser fortgehenden inneren Sonderung finden, dass sich überhaupt eine Menge Uebereinstimmungen zwischen dem Embryo höherer Tiere und der bleibenden Form niederer Tiere nachweisen lassen" (1828, p. 220). "Anstatt die anderen bestimmten Formen zu durchlaufen, scheidet sich vielmehr, jeder Embryo einer bestimmten Tierform von ihnen. Im Grunde ist also nie der Embryo einer höheren Tierform einer anderen Tierform gleich, sondern nur ihrem Embryo. Nur dadurch, dass die am wenigsten ausgebildeten Tierformen vom Embryonenzustand sich wenig entfernen, behalten sie einige Aehnlichkeit mit den Embryonen höherer Tierformen. Diese Aehnlichkeit ist also, wenn unsere Darstellung gegründet ist, auf keine Weise das Bedingende der Entwicklungsgeschichte höherer Tiere, sondern nur eine Folge der Organisation der niederen" (p. 224). "Der Embryo geht nie durch eine andere Tierform hindurch, sondern nur durch den Indifferenzzustand zwischen seiner Form und einer anderen" (p. 230). "Mithin durchlaufen die Embryonen der Wirbeltiere in ihrer Entwicklung gar keine bekannten bleibenden Tierformen" (p. 220).

In spite of this correct summary of the views of von Baer, Hertwig, in the same article, strangely enough wrote (p. 37): "Die Lehre von der Parallele zwischen der 'individuellen Metamorphose' und 'der Metamorphose des Tierreiches' (C. E. v. BAER, 1828, p. 201) war am Anfang unseres Jahrhunderts unter Anatomen und Physiologen weit verbreitet. Als Gewährsmann hierfür sei C. E. v. BAER citiert (1828, p. 199)." The previous quotations from von Baer show clearly that he held views directly opposite to those attributed to him here by Hertwig and that it is wrong to call him a guar-

antor "Gewährsmann" of the idea of parallelism except in a very restricted sense. In a discussion which bears the marginal notation "Folgerungen, die man hierauf gebaut hat," von Baer says (pp. 200-201):

Eine unvermeidliche Folge jener als Naturgesetz betrachteten Vorstellungsweise war die, dass eine früher herrschende, seitdem ziemlich allgemein als unbegründet betrachtete Ansicht von der einreihigen Stufenfolge der verschiedenen Thierformen allmählig wieder festern Fuss gewann, und wenn auch oft nicht deutlich ausgesprochen, ja selbst ohne Bewusstseyn der Forscher bei Urtheilen über thierische Formen in Anwendung kam. Auch muss man gestehen, dass, wenn jenes Naturgesetz angenommen wurde, die Consequenz ebenfalls die Aufnahme dieser Ansicht forderte. Man hatte dann nur *Einen* Weg der Metamorphose, den der fernern Ausbildung, entweder erreicht in Einem Individuum (*die individuelle Metamorphose*), oder durch die verschiedenen Thierformen (*die Metamorphose des Thierreiches*), und die Krankheit durfte man geradezu eine *rückschreitende Metamorphose* nennen, weil eine einreihige Metamorphose wie eine Eisenbahn nur vorwärts oder rückwärts gehen lässt, nicht zur Seite.

It was a real surprise to find that in the historical introduction to the *Handbuch der Entwicklungslehre der Wirbeltiere*, from which the above quotations from Hertwig were taken he quoted a sentence, only the last portion of which I was able to find in von Baer. This sentence reads as follows (p. 43): "Da der Keim das unausgebildete Tier selbst ist, so kann man nicht ohne Grund behaupten, dass die einfache Blasenform die gemeinschaftliche Grundform ist, aus der sich alle Tiere nicht nur der Idee nach, sondern historisch entwickeln." That Hertwig recognized that these words seem to contradict von Baer is shown by his introductory statement that they were not necessarily contradictory of other conceptions held by von Baer. Hertwig wrote (p. 43): "Zu diesem Gedankegang [That contained in the previous quotation] ist es als kein

Widerspruch zu betrachten, wenn in demselben Scholion BAER auf die Frage, ob nicht im Beginne der Entwicklung alle Tiere sich im wesentlichen gleich sind und ob nicht für alle eine gemeinsame Urform besteht, die öfters citierte Antwort giebt (p. 224)." (Here follows the above sentence.) Since the word of Hertwig carried great weight and since the comprehensive *Handbuch* of which he was editor had a very wide distribution, one is prompted to believe that he was largely responsible for widespread misconceptions regarding von Baer and the theory of recapitulation.

FRITZ MÜLLER

The confusion that exists regarding von Baer is duplicated in the case of Fritz Müller. Locy (1908), who gave a good statement regarding the theory of recapitulation, declared that: "It was suggested in the writings of von Baer and Louis Agassiz, but received its first clear complete expression in 1863 in the writings of Fritz Müller. . . . It received its most sweeping application in the work of Ernest Haeckel." In his recent text-book on embryology, Jordan (1926), while writing upon recapitulation, likewise wrote: ". . . but it was first clearly formulated by Fritz Müller in 1863, and received its most sweeping application in the works of Haeckel (1866)." Arey, in a similar text, wrote to the same effect in 1931, saying: "This law of recapitulation was first stated clearly by Müller in 1863, and was termed by Haeckel, the law of biogenesis." Since none of these three authors referred to a particular publication of Müller's, it is possible that they depended upon the statement of Haeckel and certain British writers. I think it probable that Locy depended upon the words of Haeckel for his information and that others may have depended upon

Locy, who was specially interested in the history of biology.

In a translation of Haeckel's *Die Natürliche Schöpfungsgeschichte* by Lankester, it is stated that: "When Darwin, in 1859, at last accomplished this, he also in his fourteenth chapter of his chief work, briefly referred to the great importance of embryonic evidence. Still Fritz Müller was the first to discuss the subject fully and clearly, which he did in connection with crustacea in his admirable work, *Für Darwin*." Marshall (1894) likewise wrote: "... such is the recapitulation theory, hinted at by Agassiz, and suggested more directly in the writings of von Baer, but first clearly enunciated by Fritz Müller, and since elaborated by many, notably by Balfour and by Ernst Haeckel. . . . It was the elder Agassiz who first directed attention to the remarkable agreement between the embryonic growth and their paleontological history." A little farther on, Marshall spoke of "... the clear enunciation of the recapitulation theory of Fritz Müller."

It is highly significant, it seems to me, that Müller made no claim to authorship of the recapitulation theory and it is of special interest that he rejected the conceptions on recapitulations first brought to his attention by his "unforgettable teacher," Johannes Müller. These were those of von Baer, which he said he had entertained for many years, "lange Jahre." Fritz Müller also controverted the statement of Agassiz, of whom and of Johannes Müller he nevertheless spoke as the most trustworthy or authoritative masters, "bewährtesten Meister."

Fritz Müller's essay entitled *Für Darwin* was dated Destero, September 7, 1863, but it was not published by Engelmann, of Leipzig, until 1864. I mention these facts merely because sometimes the one and

sometimes the other year is given for this article. In subdivision ten of this essay, as found on pages 242-248 of Müller's *Werke, Briefe und Leben*, edited by Möller, is stated that one can scarcely speak of a typical manner of development of crustacea through individual groups such as orders, families, etc., and Müller emphasized that this should be possible if, as according to the teachings of the schools, the type of the organism is revealed most clearly during its development. He then quoted from Johannes Müller and Agassiz regarding their ideas on this matter. Fritz Müller's comment upon these quotations suggests that he no longer held the views of his revered teacher Johannes, to the effect that embryology can serve as a control in the classification of organisms, because as he said, the idea of development implies not merely an increase in size but also a progressing differentiation from which it follows that the earlier the stage of development of an organ, the more it resembles the type, and that the types of comparative anatomy and embryology should hence agree.

In commenting upon a quotation from Johannes, Fritz correctly stated that the former attacked the idea that a progressive series, "Stufenleiter," or scale in the sense of Aristotle, exists among animals and that they pass through a number of "Thierstufen" during development. He then quoted further from his namesake to the effect that the truth in these ideas lies in the fact that an embryo in the early stages of development bears evidence of the "Abtheilung" from which only the type of its class, order, etc., develops later on. Fritz unfortunately did not give the source of this quotation from Johannes but the ideas were expressed previously by von Baer in connection with the discussion of the subject of recapitula-

tion in his *Entwicklungsgeschichte*. In his *Physiologie des Menschen* Johannes wrote as follows (p. 716):

Am Schlusse dieser Uebersicht über die allgemeinsten Entwicklungen im Ei des Menschen ist die schon gelegentlich berührte Frage ausführlicher zu erörtern, wie die Aehnlichkeiten, welche die Embryonen in den verschiedenen Classen mit einander darbieten, anzusehen sind. Es ist noch nicht sehr lange her, dass mehrere Naturforscher die Idee aufstellten und ganz ernstlich nahmen, dass der Menschenfötus die niederen Thierstufen bis zum Menschen durchlaufe, und dass er in den verschiedenen Perioden des Fötuslebens verschiedenen Thierstufen gleiche. In dieser Weise ausgedrückt klingt jene Aehnlichkeit sehr abentheuerlich und findet auch in keiner Weise statt, wie v. BAER sehr schön gezeigt hat. Denn der Embryo gleicht in der That nie weder einem Strahlenthier, noch einem Insect, noch einem Molluscum, noch einem Wurme. Die Formationspläne dieser Thiere sind eben himmelweit von dem der Wirbelthiere verschieden. Der Mensch konnte daher höchstens seinen Verwandten ähnlich seyn, nämlich den Wirbelthieren, da er selbst Wirbelthier ist und mit ihnen den allgemeinen Plan der Wirbelthiere theilt. Er gleicht aber, auch nicht zu gewisser Zeit einem Fisch, zu anderer einem Amphibium, Vogel u.s.w.; sondern er gleicht einem Fisch gerade so weit er einem Vogel und Amphibium gleicht, oder wie fern alle diese Wirbelthiere sind. Anfangs tragen aber die Embryonen aller Wirbelthiere das Gemeinsame und Einfachste vom Typus eines Wirbelthiers am reinsten an sich, und daher gleichen sich die Embryonen aller Wirbelthiere in der ersten Zeit so sehr, dass es oft schwer ist, sie von einander zu unterscheiden. Fisch, Amphibium, Vogel, Säugethier und Mensch stehen also anfangs dem einfachsten gemeinsamen Typus am nächsten, und entfernen sich allmählig davon, so dass die Extremität anfangs gleich, die Bestimmung zu Flosse, Flügel, Fuss, Hand u.s.w. erhält. Deswegen haben alle Embryonen anfangs Bogen am Halse und Spalten dazwischen, die uneigentlich sogenannten Kiemenbogen, ein Ausdruck des allgemeinen Plans, an welchem in der That noch nichts von einer Kieme ist. In diesen Bogen verlaufen bei allen Thieren Aortenbogen, die sich hinten zur Aorta wieder vereinigen. Nur bei den Fischen entsteht hier eine progressive Metamorphose, indem sich an einigen dieser Bogen Kiemenblättchen bilden und die Gefässbogen sich in ein System von Gefässfedern mit arteriösen und venösen Stämmen verwandeln, welche letztere dann erst wieder die Aorta zusammensetzen.

Bei den nackten Amphibien geschieht das auch, aber ihre Kiemen vergehen bei der Verwandlung, ihre Kiemengefässe werden wieder auf die ursprünglichen unverzweigten Bogen reducirt und ihre Kiemenbogen gehen grösstentheils ein, wie sie bei den beschuppten Amphibien, Vögeln, Säugethieren und dem Menschen überhaupt sogleich in andere perennirende Bildungen verwandelt werden. Hier gehen auch die mehrfachen Aortenbogen, Ausdruck des allgemeinsten und einfachsten Plans der Wirbelthiere, ein, und es bleiben bei den beschuppten Amphibien nur entweder 4 oder 2, bei den Vögeln, Säugethieren und dem Menschen nur einer übrig.

The second master to whom Fritz Müller referred in his criticism of recapitulation in *Für Darwin* was Louis Agassiz. He quoted the latter's *Principles of Zoology*, Part I, revised edition, Boston, 1856. These quotations are to the effect that the ovarian ova of all animals are "identical" small cells with yolk, nucleus, and nucleoli, and that the embryos of different animals resemble each other the more the younger they are. Müller added that he did not know whether any one today (1863) would be inclined to subscribe fully to such views, for all ova are alike only as all insects are alike in that they have a head, chest and abdomen, and provided one compares only what they have in common! He further indicated his dissent from Agassiz's conception of recapitulation and also took up some other statements contained in the quotation from the latter, which he said are wholly untenable.

It is significant that in *Für Darwin*, Fritz Müller especially considered but rejected, the very thing that his "unforgettable" teacher, Johannes, had regarded as the sole truth in the idea of recapitulation, namely, that "Embryonen, Jugendzustände verschiedener Thiere gleichen einander um so mehr, je jünger sie sind, oder wie Johannes Müller es ausdrückt, nähern sich um so mehr dem gemeinsamen Typus." Fritz Müller pointed out that there are many exceptions to this idea

which is frequently and rightly spoken of as von Baer's law, and that these exceptions occur in very closely related organisms in which the opposite is true. He then turned to the development of crustacea and declared that a study of them gives a truthful picture of the transformations through which the species passed in the course of countless thousands of years up to its present stage of development, and this of course was recapitulation, with emphasis upon its historical aspect. However, Müller made no special formulation of his recapitulation idea but brought proof in support of a certain aspect of it and especially of evolution. Others had already contributed the phylogenetic and paleontologic aspects of the theory. This was recognized by Thomson (1917) who wrote: "In Fritz Müller's *Facts for Darwin*, the recapitulation idea was applied in detail to Crustaceans. . . ."

As the title of *Für Darwin* suggests, Müller's main conclusion was that his studies on the development of crustacea confirmed Darwin's idea of evolution. This is evident especially from the concluding paragraph in this essay, which reads as follows:

Manches in den obigen Aufstellungen mag verfehlt sein, manche Deutung misslungen, manche Thatsache nicht ins rechte Licht gestellt. Eines aber, hoffe ich, soll mir gelungen sein,—unbefangene Leser zu überzeugen, dass wirklich Darwin's Lehre, wie für so viele andere ohne sie unerklärbare Thatsachen, so auch für die Entwicklungsgeschichte der Kruster den Schlüssel des Verständnisses bietet. Die Mängel also dieses Versuches wolle man nicht dem von der sicheren Hand des Meisters vorgezeichneten Plane, man wolle sie einzig dem Ungeschick des Handlagers zur Last legen, der nicht für jedes Werkstück die rechte Stelle zu finden verstand. (Fritz Müller, *Werke, Briefe und Leben*, volume I, page 259.)

Müller's aim and conclusion hence very clearly were not the formulation of a theory of recapitulation but to bring support to Darwin. This was recognized

also by the English translators of *Für Darwin*, who rendered the title as *Facts and Arguments for Darwin*. Fritz Müller emphasized that the idea that mature forms of lower organisms represent developmental stages of the higher is illustrated especially well in the case of crustacea. He declared that he observed the development of these forms, "aus dem Gesichtspuncte der Darwin'schen Lehre," and emphasized that the story of their development often is "verwischt" because it takes a direct course to its goal and that the record also may be "gefälscht" by the struggle for existence. The last conception later was called caenogenesis by Haeckel.

My conclusion regarding the significance of Müller's *Für Darwin* is that of Nordenskiöld, who wrote: "Having from the very beginning been entirely won over to Darwin's theory, he resolved to prove it by applying it in detail to a suitable animal group, for which purpose he chose Crustacea, which in his adopted country exist in a multitude of forms." That Haeckel also recognized this as the real significance of Müller's study is indicated by his statement that Müller attempted to demonstrate the value of the theory of evolution in the study of the development of crustacea. In *Die Welträthsel*, Haeckel wrote: "Schon Darwin hatte (1859) die grosse Bedeutung seiner Theorie für die Erklärung der Embryologie betont, und Fritz Müller hatte dieselbe (1864) an dem Beispiele einer einzelnen Thierklasse, den Krustaceen, nachzuweisen versucht, in der geistvollen kleinen Schrift: 'Für Darwin' (1864)." (p. 94)

In his discussion of *Das biogenetische Grundgesetz und die Cenogenese*, Keibel (1897) declared (p. 725):

Der erste, der von dem Darwinschen Werke ausgehend die Entwicklungsgeschichte mit der Descendenztheorie in den engsten Zusammenhang brachte, war

Fr. Müller. Nach Fr. Müller ist die Entwicklungsgeschichte des Individuums als eine kurze und vereinfachte Wiederholung, gewissermassen als eine Rekapitulation des Entwicklungsganges der Arten aufzufassen. Müllers Untersuchung, die in seiner Arbeit 'Für Darwin' niedergelegt wurde, erschien 1864. Müller fusst wesentlich auf Untersuchungen an Krustern. Ich stelle hier einige der wichtigsten Sätze zusammen, zu denen er durch diese Untersuchungen geführt wurde.

These words of Keibel's, which were followed by quotations from Müller's article *Für Darwin* may also have been misinterpreted by those who did not read them critically. On the basis of his studies of crustacea, Müller considered the extent to which recapitulation might occur and how it might be modified.

AGASSIZ

Although Agassiz apparently was concerned with establishing other things than recapitulation, in his monograph on classification of 1857, the idea of phylogenetic recapitulation nevertheless is suggested in the following paragraphs from this work.

The parallelism between the order of succession of animals in geological times, and the changes their living representatives undergo during their embryological growth, exhibits thought. . . . (p. 134)

The parallelism between the gradation among animals and the changes they undergo during their growth, exhibits thought. . . . (p. 135)

Animals are linked as closely by their mode of development, by their relative standing in their respective classes, by the order in which they have made their appearance upon earth. . . . (p. 136)

In commenting upon these statements in a foot-note, Russell pertinently said (p. 203) that Agassiz "considered the classificatory categories to be the categories of the Creator's thought and hence natural, and in no sense mere conventions," and as Morgan pointed out, since Agassiz was not an evolutionist, his idea of recapitulation was "without the idea of ancestry

which the theory of evolution implied." Morgan further stated that Agassiz, in the Lowell lectures of 1848, proposed "for the first time the theory that the embryo of the higher forms resemble not so much lower adult animals living at the present time, as those that lived in past times." In a foot-note, Morgan added that "Carl Vogt in 1842 suggested that fossil species, in their historical succession, pass through changes similar to those which the embryos of living forms undergo." Montgomery also referred to Vogt (1851) in connection with his discussion of recapitulation.

DARWIN

Since G. B. T. (whose identity the publishers could not ascertain) in the introduction to *A Journal of Researches*, by Charles Darwin, says that: "It would be useless to attempt to expound the doctrines of . . . the facts of the stages through which embryos of animals pass, resembling simpler animals or the early stages of widely different animals," it is well to inquire regarding Darwin's ideas concerning recapitulation. In *The Origin of Species*, Darwin, when quoting approvingly from von Baer, wrote (pp. 387-88):

So again it has been shown that generally the embryos of the most distinct species belonging to the same class are closely similar, but become, when fully developed, widely dissimilar. . . . A trace of the law of embryonic resemblance occasionally lasts till a rather late age. . . . (p. 396) Thus, community in embryonic structure reveals community of descent; but dissimilarity in embryonic development does not prove discommunity of descent, for in one of two groups the developmental stages may have been suppressed, or may have been so greatly modified through adaptation to new habits of life, as to be no longer recognisable. . . . As the embryo often shows us more or less plainly the structure of the less modified and ancient progenitor of the group, we can see why ancient and extinct forms so often resemble in their adult state the embryos of existing species of the same class.

It will be recalled that Darwin himself published several volumes on fossil and living barnacles and acorn shells during 1851 and 1854. He hence was especially interested in the work of Fritz Müller on the same group, and it is noteworthy that he apparently did not regard the latter as the author of the theory of recapitulation and that he also correctly understood the position of von Baer.

Vogt, Tiedemann and Agassiz called attention to the paleontological evidence and Fritz Müller, while rejecting the idea of recapitulation of Johannes Müller and Agassiz and by inference also that of von Baer, found that recapitulation in modified form is particularly well-illustrated in the development of certain crustacea. He did not at all claim to have formulated a theory of recapitulation and considered recapitulation in the light of evolution. This meant stress on descent. Müller also declared that the ontogenetic record is modified by the struggle for existence, "Kampfums Dasein," during development, and also by abbreviation of the latter in consequence of a tendency on the part of the organism to take a short cut.

Haeckel's formulation made recapitulation into a slogan but this could not make it a law, though his enthusiastic advocacy of it stimulated much work in embryology. It was he especially who regarded

it as a law and defended it in a very outspoken way. However, not even Haeckel went so far as did Thomson (1917) when he declared that: "... there is an ever-growing mass of facts relating to peculiar psychoses in child and adult which we must recognize as vestigial and recapitulatory." But this raises the question of the validity of the law and with that I am not concerned here. Any reader desiring information on this aspect of the subject will find the discussions of Cumings, Cunningham, Davidson, Gaskell, Garstang, Lankester, Montgomery, Morgan, Russell, Sedgwick, Sewertzoff and Shumway of special interest not only for the subject matter but for the references to the literature which they contain. For the information of readers I will also add that this discussion was given as an address before the Western Society of American Naturalists in December, 1932, and that this fact very largely determined its form and content. Articles which have appeared since that time are hence not considered except that I should direct attention to the fact that Zirkle in a very recent historical review of the idea of the inheritance of acquired characters, declared that Haeckel is "the inventor of the biogenetic law" and accused him of "intellectual inertia"!

LIST OF LITERATURE

- AGASSIZ, LOUIS. *Principles of Zoology*. Revised edition. *Boston*, 1856.
- . *Essays on Classification*. Pt. I, Vol. I. Contrib. to Nat'l Hist. of the U. S. *Boston*, 1857.
- AREY, LESLIE BRAINERD. *Developmental Anatomy*. Second edition. *Philadelphia and London*, 1931.
- ARISTOTLE. *De Generatione Animalium*. Arthur Platt, *Oxford*, 1910-12.
- VON AUTENRIETH, JOHANNES FERDINANDUS HENRICUS. *Observationum ad historiam embryonis facientium, pars prima, formam illius externam actatem et involucri, methodumque palato fissio medendi vero-simillimam sistens*. *Tubingae* (1797) p. 20. (After Meckel, 1828).
- VON BAER, KARL ERNST. *Über Entwicklungsgeschichte der Thiere*. *Königsberg*, 1828.
- BALSS, HEINRICH. *Kielmeyer als Biologe*. *Sudhoffs Archiv für Geschichte der Medizin*, Bd. 23, 1930, pp. 268-88.
- DE BLAINVILLE, HENRI-MARIE-DUCROTAY. *Sur la dégradation du cœur et des gros vaisseaux, chez les ostéozoaires*. *Bulletin de la Soc. Philom.*, 1819. (After Meckel, 1828.)

- BLUMENBRACH, JOH. FRIEDRICH. De anomalis vitiosis quibusdam nisis formativi aberrationibus commentatio. *Göttingen*, 1813, p. 6. (After Meckel, 1828.)
- BUTTERSACK, FELIX. Karl Friedrich Kiemeier (1765–1844). Ein vergessenes Genie. *Sudhoffs Archiv für Geschichte der Medizin*, Bd. 23, 1930, pp. 236–46.
- CARLISLE, ANTHONY. Muscular motion. Croonian lecture, 1804, p. 5. *Philos. Tr. R.S.L.*, 1805.
- CARUS, KARL GUSTAV. Lehrbuch der Zoötomie. *Leipzig*, 1818, p. 667. (After Meckel, 1828.) Only the edition of 1834 was accessible to me.
- . Versuch einer Darstellung des Nervensystems u. insbesondere des Gehirns nach ihrer Bedeutung, Entwicklung u. Vollendung im thierischen Organismus. *Leipzig*, 1814.
- CARUS, J. VICTOR. Geschichte der Zoologie bis auf Joh. Müller und Charl. Darwin. *München*, R. Oldenbourg, 1872.
- COLE, F. J. Early Theories of Sexual Generation. *London, Oxford*, 1930.
- CUMINGS, E. R. Paleontology and the recapitulation theory. *Proc. Ind. Acad. Sci.*, 1908–09.
- CUNNINGHAM, J. T. Recapitulation. *Science Progress*, VI, Vol. 1, 1897.
- DARWIN, CHARLES. A Journal of Researches. (With an introduction by G. B. T.) *New York*, Harper & Bros., no date. World Library Series.
- . On the Origin of Species by Means of Natural Selection. New edition, from the sixth English edition, with additions and corrections. *New York*, D. Appleton and Co., 1889.
- DAVIDSON, PERCY E. The Recapitulation Theory and Human Infancy. *New York*, 1914.
- GARRISON, FIELDING H. An Introduction to the History of Medicine, with Medical Chronology, Bibliographic Data and Test Questions. *Philadelphia and London*, 1913.
- GARTANG, W. The theory of recapitulation. *Journal Linnean Society of London, Zoology*, Vol. 35, 1922.
- GASKELL, WALTER HOLBROOK. The Origin of Vertebrates. *London and New York*, 1908.
- GEDDES, PATRICK, and J. ARTHUR THOMSON. Evolution. *New York and London*, 1911.
- HAECKEL, ERNST. Die Welträthsel. *Bonn*, 1900.
- . Generelle Morphologie der Organismen. *Berlin*, 1866.
- . History of Creation. Fourth edition, translated by E. Ray Lankester. *New York*, 1892.
- HARVEY, WILLIAM. The Works of. Translated from the Latin with a life of the author, by Robert Willis. *London*, Sydenham Society, 1847.
- HERTWIG, W. H. OSKAR. Einleitung und allgemeine Litteraturübersicht. Handbuch der vergleichenden und experimentellen Entwicklungslehre der Wirbeltiere. Bd. I, Teil I, Hälfte 1. *Jena*, 1906.
- HOLMES, S. J. Life and Evolution. *New York*, 1926.
- HUNTER, JOHN. Observations on Certain Parts of the Animal Economy, with notes by Richard Owen. *Philadelphia*, 1840.
- . Essays and Observations on Natural History, Anatomy, Physiology, and Geology. Being his posthumous papers on those subjects, arranged and revised with notes; to which are added, the introductory lectures on the Hunterian collection of fossil remains, delivered in the theatre of the Royal College of Surgeons of England, March 8th, 10th, and 12th, 1855: By Richard Owen. *London*, 1861, vol. 1.
- JORDAN, HARVEY ERNEST, and JAMES ERNEST KINDRED. A Textbook of Embryology. *New York and London*, 1926.
- KEIBEL, FRANZ. Das biogenetische Grundgesetz und die Cœnogenese. *Ergebn. d. Anat. u. Entwicklungsgeschichte*, Bd. 7, 1897.
- KELLOGG, VERNON. Evolution, the Way of Man. *New York and London*, 1924.
- KIELEMEYER, CARL FRIEDRICH. Über die bei allen einzelnen Pflanzen wahrnehmbare Richtung ihrer Wurzeln nach unten erdwärts u. die Richtung der Stämme nach oben, himmelwärts. Eröffnungsrede 12. Naturforsch.-Versammlung 1834 zu Stuttgart. (After Balss.)
- . Ueber die Verhältnisse der organischen Kräfte unter einander in der Reihe der verschiedenen Organisationen, die Geseze und Folgen dieser Verhältnisse. Eine Rede den 11ten Februar 1793 am Geburtstage des regierenden Herzogs Carl von Württemberg, im grossen akademischen Hörsale gehalten. Reprinted in *Sudhoffs Archiv für Geschichte der Medizin*, Bd. 23, 1930, pp. 247–67.
- LANKESTER, E. RAY. Zoology, in *Encyclopædia Britannica*, Eleventh edition, 1911.
- LEAKE, CHAUNCEY D. Anatomical Studies on the Motion of the Heart and Blood. *Springfield, Ill., and Baltimore, Md.*, 1931.
- LOCY, WILLIAM A. Biology and Its Makers. Third edition, revised. *New York*, 1928.
- MARSHALL, ARTHUR MILNE. The Recapitulation Theory. *Biological Lectures and Addresses*, *London*, Chpt. xiii, 1894.
- MECKEL, JOHANNES FRIDERICUS. Abhandlungen aus der menschlichen und vergleichenden Anatomie und Physiologie, S. 288ff. *Halle*, 1806. (After Meckel, 1821.)

- MECKEL, JOANNES FRIDERICUS. *Beiträge zur vergleichenden Anatomie*. Bd. 2, H. 1, S. 1-60. *Leipzig*, 1811. (See p. 409, Meckel, 1821.)
- . *System der vergleichenden Anatomie*. Erster Theil, Allgemeine Anatomie. Renger, *Halle*, 1821.
- . *Traité Général d'Anatomie Comparée*, traduit de l'Allemand et Augmenté de Notes par MM. Riester, et Alph. Sanson. *Paris*, 1828.
- MONTGOMERY, T. H. *Analysis of Racial Descent in Animals*. Henry Holt & Co., *New York*, 1906.
- MINOT, CHARLES SEDGWICK. *A Laboratory Text-book of Embryology*. Second edition, revised. *Philadelphia*, 1910.
- MORGAN, THOMAS HUNT. *Evolution and Adaptation*. *New York*, 1903.
- MÜLLER, FRITZ. Für Darwin, in *Werke, Briefe und Leben*. *Jena*, 1915.
- MÜLLER, JOHANNES. *Handbuch der Physiologie des Menschen*. Zweiter Band. *Coblenz*, J. Holscher, 1840, p. 716.
- MÜNTER, GUSTAV WILHELM. *Allgemeine Zoologie oder Physik der organischen Körper*. *Halle*, 1840. (After Balss.)
- NEEDHAM, JOSEPH. *Chemical Embryology*. *Cambridge*, 1931.
- NORDENSKIÖLD, ERIK. *The History of Biology*, translated from the Swedish by Leonard Bucknall Eyre, *New York and London*, 1929.
- OKEN, LORENZ. *Die Zeugung*. *Bamberg*, 1805. (Oken stated this first appeared at "Frankfurt bey Wesche, 1805.")
- . *Lehrbuch der Naturphilosophie*. Dritte, neu bearbeitete Auflage. *Zürich*, 1843. (Oken stated that the first edition appeared in 1810 and 1811.)
- OKEN, LORENZ, und D. G. KIMMER. *Beiträge zur vergleichenden Zoölogy, Zoöatomy und Physik*. *Bamberg*, 1806. (After Meckel.)
- RÄDL, EM. *Geschichte der biologischen Theorien seit dem Ende des siebzehnten Jahrhunderts*. I. Teil. *Leipzig*, 1905.
- RUSSELL, E. S. *Form and Function, a Contribution to the History of Animal Morphology*. *London*, 1916.
- SEDGWICK, ADAM. *Embryology*, in *Encyclopaedia Britannica*, Eleventh edition, 1911.
- . On the law of development commonly known as von Baer's law; and on the significance of ancestral rudiments in embryonic development. *Quart. Jr. Micros. Sci.*, 36, 1894.
- SEWERTZOFF, A. N. Über die Beziehungen zwischen der Ontogenese und der Phylogenese der Tiere. *Jenaische Zeitschrift für Naturwissenschaft*, Bd. 63, Heft 1, Mar. 4, 1927. (Issued 1928.)
- SHUMWAY, WALDO. The recapitulation theory. *THE QUARTERLY REVIEW OF BIOLOGY*, Volume 7, 1932.
- THOMSON, J. ARTHUR. *Darwinism and Human Life*. (New edition enlarged, with illustrations by E. L. Shinnie.) Henry Holt & Co., *New York*, 1917.
- TIEDERMANN, FR. *Zoologie*, Bd. I. (After Meckel, 1828.)
- . Beobachtung einer Schwangerschaft bei einer sogenannten doppelten Gebärmutter. J. F. Meckel, *Deutsches Archiv für die Physiologie*, V. Bd. *Halle und Berlin*, 1819, pp. 131-135.
- VOGT, C. *Zoologische Briefe*. *Frankfurt a.M.* (After Meckel.)
- VON WALTHER, PHILIPP FRANZ. *Physiologie des Menschen mit durchgängiger Rücksicht auf die comparative Physiologie der Thiere zu akademischen Vorlesungen bearbeitet*. *Landsbut*, 1807-8. Vol. 2. (After Meckel, 1828.)
- WHITMAN, O. C. *Palingenesis and the germ doctrine of Bonnet*. *Biological Lectures*, Woods Holl. *Boston*, 1896.
- WILSON, EDMUND B. *The embryological criterion of homology*. *Biological Lectures*, Woods Holl. *Boston*, 1896.
- WOODRUFF, LORANDE LOSS. *Foundations of Biology*. *New York*, 1923.
- ZIRKLE, CONWAY. The inheritance of acquired characters and the provisional hypothesis of pangenesis. *The American Naturalist*, vol. 59, pp. 417-445, 1935.



MORPHOGENESIS OF THE SHOULDER ARCHITECTURE

PART III. AMPHIBIA

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IN A previous contribution to this series of papers the author (1933) discussed briefly the general situation obtaining in the region of the shoulder girdle in fishes. In the present part Amphibia will be considered. In this class there are similar problems encountered, in that living representatives have had just as long a time to develop tangential specializations since they diverged from the common tetrapod ancestor as have the higher vertebrates; and fossil remains, although of help in some respects, are misleading in others.

In the class Pisces the morphological trend was largely toward the development of a fin useful in swimming. In the terrestrial Amphibia, on the contrary, the objective was towards limbs suitable for walking. It is not at all improbable that the change from fin to limb form proved to be a less difficult matter for the vertebrates than the development of the mechanism within the central nervous system whereby the body was held above the ground while steps were being taken. This—the acquisition of posture—must have had the most profound effect in accelerating or retarding different lines of vertebrate evolution, and yet it has been universally ignored by morphologists. An inability to develop a higher type of nervous posture may well have prevented the ancestors of modern amphibians from joining the tetrapod line of ascent, condemning them to the relinquishment of the terrestrial objective.

CROSSOPTERYGIAN STAGE

It was stated in the section on Pisces that the significance of rhipidistian crossopterygian fossils could be discussed better with amphibians than with fish. It will also be necessary to mention certain myological and neurological details of *Polypterus* in this connection.

There appears to be ample reason for considering that the skeletal details of Devonian crossopterygians fulfilled the basic requirements necessary for the tetrapod ancestry. In the shoulder region they had a membranous girdle consisting of supracleithrum above, a large cleithrum, and an anteroventrally directed clavicle. Presumably also there was connection to the skull through a post-temporal. Details in *Sauripterus* and *Eusthenopteron* appear to have been essentially similar, but are indicated with more precision in known remains of the latter, and so that form is used for illustration (fig. 1). The base of the small scapulocoracoid was bifurcated in *Eusthenopteron*, but seems to have been relatively larger in *Sauripterus* with the possibility that in that genus it may have been more completely separable into distinct parts.

Of the more distal elements there is good material representing both genera, and these agree in plan of elements constituting humerus, radius, and a considerably longer ulna. It can hardly be doubted that in antibrachial details they follow a plan that was truly ancestral.

In an attempt to interpret the basic carpal plan one may build a plausible story around almost any attractive thesis, and *Eusthenopteron* may be so employed. This crossopt offers one difficulty, however, which appears to be almost insurmountable, in the fact that its endoskeletal elements were so few (fig. 2). These are clearly shown in the illustrations of Bry-

der elevated and postaxial depressed. In spite of this fact it has been uniformly considered that the preaxial border was the one depressed in Devonian crossopts, until Romer and Byrne (1931) pointed out the error. Hence the ulna is the more ventral of the antibrachial bones, and it is much longer in *Sauripterus* than the radius. Other significant details consist

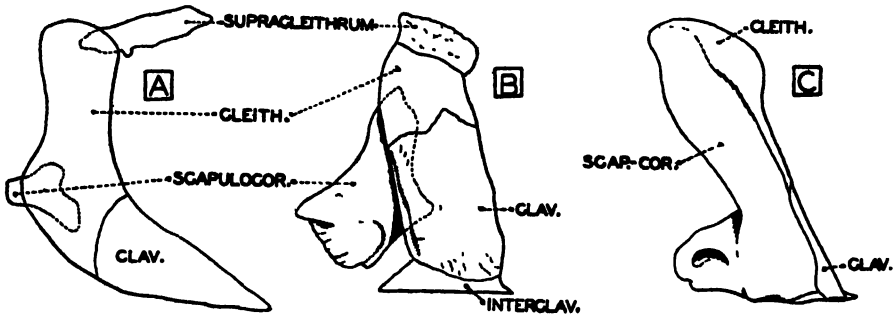


FIG. 1. RIGHT SHOULDER BONES OF (A) *EUSTHENOPTERON* (BRYANT), (B) *EOGERYNUS* (WATSON), AND (C) *ERYOPS*, FROM THE LATERAL ASPECT

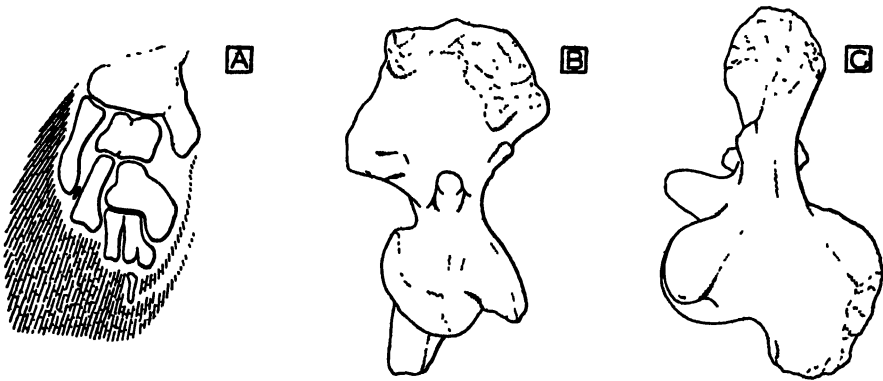


FIG. 2. (A) THE LEFT PECTORAL FIN OF *EUSTHENOPTERON* (BRYANT), (B) ANTERIOR, AND (C) DORSAL, VIEWS OF LEFT HUMERUS OF *ERYOPS* (FROM CAST IN AMER. MUS. NAT. HIST.); PROXIMAL END ABOVE

ant (1919) and it is evident that no additional cartilages were hidden by the dermotrichia. On the other hand, *Sauripterus* offers no such difficulty, and it has already been indicated (Howell, 1935) how its fin plan might have been altered to fit the arrangement in *Eryops*.

It is a rule that the pectoral fins of fish have become rotated, with preaxial bor-

der elevated and postaxial depressed. In spite of this fact it has been uniformly considered that the preaxial border was the one depressed in Devonian crossopts, until Romer and Byrne (1931) pointed out the error. Hence the ulna is the more ventral of the antibrachial bones, and it is much longer in *Sauripterus* than the radius. Other significant details consist

Broom (1913) has mentioned the circum-

stage that when fish first took to the land there must have been a lengthy period when the paired fins functioned with fair efficiency as both limbs and fins. In other words the part of the pectoral fin having had chief contact with the ground must have become modified to act as a limb while the remainder of the appendage lagged behind, still being a fin. This would develop an appendage essentially asymmetrical, as was that of *Sauripterus*. This inequality in the length of the ulna and the fact that the latter is so much the

ulna are situated at three different levels (fig. 3), a detail of much significance. If, in *Sauripterus*, one concede the presence of prepollex and postminimus elements shorter than the others, there are left six radialia. For the present it appears advisable to ignore the presence of one of these, assuming either that it disappeared, or that the actual crossopt ancestral to tetrapods had one less radial than *Sauripterus*.

In the transition from fish to amphibian one must consider the probabilities in the

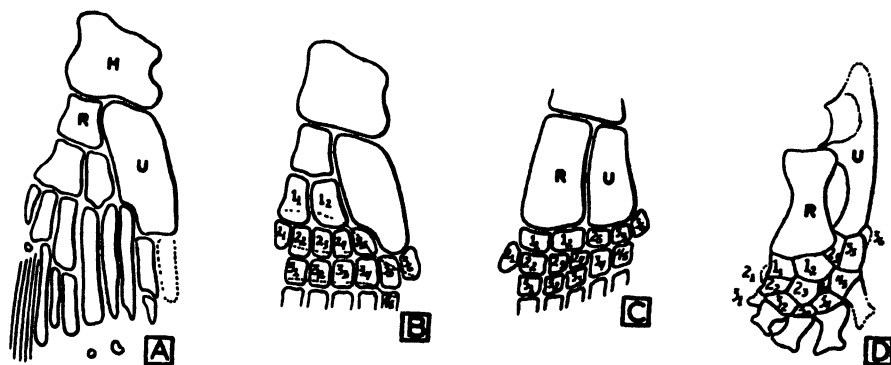


FIG. 3. POSSIBLE EARLY MORPHOLOGY OF THE CARPUS

(A) Lateral view of anterior appendage of *Sauripterus*, transposed to represent left fin (after Gregory); (B) Hypothetical, post-*Sauripterus* stage, showing probable division of carpal cartilages into transverse rows; the broken lines pass through the elements which will be associated transversely in later stages; (C) Hypothetical, pre-*Eryops* stage, indicating arrangement of the carpal elements shown in (C) according to the *Eryops* plan; (D) The forearm and hand of *Eryops* (after Gregory, Miner and Noble), the elements numbered according to their homologues in (B).

more robust in this genus constitutes evidence of considerable weight that this crossopt was partially terrestrial. On the other hand, conditions in *Eusthenopteron*, and particularly the fact that the dermotrichia were still strongly developed over the ulnar border, as shown in Bryant's splendid photographs, may indicate that this genus was not so terrestrially inclined, or possibly that it was retrogressive, having secondarily returned completely to the water.

It will be seen in *Sauripterus* that the carpal bones next distal to the radius and

post-crossopt stage. Watson (1913) has pointed out that the endoskeletal elements of the appendage proper were originally all of the same order. They could elongate, shorten, or undergo fission or fusion as the stimulus was encountered. It is certainly likely that the radialia of *Sauripterus* later divided into shorter elements, not improbably all of about the same length, as suggested in the diagram of the hypothetical condition in figure 3. It will be noted that the ones next distal to radius and ulna lie at three different levels. It will also be observed that in this dia-

gram there has been discarded one of the radialis distal to the carpal element marked r_1 which appears to be a necessary corollary as above stated. The remainder of the carpal elements are discussed subsequently.

The appendageous skeleton of the living crossopt *Polypterus* is so tangentially specialized that it is hardly worth mentioning in the present connection. This being so, one must look upon the arrangement of its soft parts with considerable suspicion. Yet it is all we have, and if considered on a broad enough basis one may obtain some evidence of value from this source.

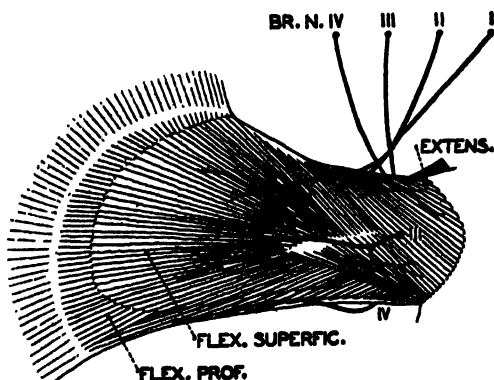


FIG. 4. LATERAL (FLEXOR) ASPECT OF THE RIGHT PECTORAL FIN OF *POLYPTERUS*, SHOWING TWISTING OF NERVES AND THEIR DISTRIBUTION UPON THIS SURFACE.

In *Polypterus* the pectoral fin musculature is divisible into a superficial and deep extensor muscle medially, and a superficial and a deep flexor laterally, with minor slips of the two divisions. More detailed examination shows, however, that superficially the flexor surface is divided by an irregular raphe into proximal and distal portions (fig. 4). They are functionally separable, although the differentiation of these and other elements is not as exaggerated as indicated in Klaatsch's (1896) figures (extensors and flexors are reversed in his paper). Pulling on the proximal part advances the whole shoulder, and on

the distal part, merely the fin proper. Thus the fin musculature may be divided into extensor (medial) and flexor (lateral) divisions, and the flexor mass again divided into shoulder and "brachial" portions. During the "unrotation" of the fish fin to the subsequent amphibian posture this shoulder division of the flexor musculature might exhibit some tendency to remain aligned dorsally with the extensors,—a phenomenon which could explain the later dorsal allocation of the supraspinous matrix. It is not believed that this is so, but it is a possibility that must be considered.

I previously (1933b) stated that the first brachial nerve of *Polypterus* appeared to innervate only the flexor musculature. This may have been a variation, or I may well have unwittingly destroyed a nerve branch, for the single specimen which I dissected was poorly preserved. Subsequent dissection leads me to believe that facts are substantially the same as stated by Klaatsch. This, in brief, is to the effect that the first and second brachial nerves join, and the branches thereof supply both flexors and extensors along the preaxial (more dorsal) border of the fin, including the more preaxial part of the shoulder flexor. The second brachial nerve supplies the central part of the extensor mass and a branch pierces the "coracoid foramen" to the corresponding part of the flexor group, including the more postaxial part of the shoulder flexor. The fourth brachial nerve passes to the postaxial border of the fin and supplies the extreme postaxial part of the flexor complex and slightly more of the extensor surface. These nerves are crossed proximally, in accordance with the way the fin has become rotated. The arrangement is shown in figure 4.

It is believed probable that *Polypterus* offers a fairly precise picture of the basic

arrangement of the brachial nerves, comprising three trunks, all of which go usually to both extensor and flexor musculature, the first to the preaxial fin border, the second to the central zone, and the third to the postaxial border.

One can only compare these nerve elements with those of higher tetrapods in the most general way. Only two ideas can be advanced with any feeling of confidence: the first that if the suprascapular nerve and musculature of higher forms be represented in *Polypterus* it is by the branch of the first brachial trunk going to the more preaxial part of the shoulder flexor, and the other is either that the flexor branch of the fourth brachial nerve and the restricted part of the flexor musculature which it supplies have been lost in higher forms, or (less likely) that the nerve has come to follow another pathway. This conclusion is offered by the fact that in tetrapods there is no nerve to any of the brachial flexors following a pathway around the postaxial border and over the triceps musculature to the flexors. Romer's (1924) conclusion that this flexor branch of *Polypterus* represents the axillary nerve, and hence that the latter and its musculature constitute a flexor component is hardly tenable, for the whole course of phylogeny offers satisfactory evidence that this is a part of the extensor complex. Again, in Romer's illustration of this point (his fig. 10) he compares the course of the nerves of *Polypterus* with higher forms without having first "unrotated" the fin of the former, so that he compares the preaxial border of the fish with the postaxial of tetrapods. An additional point for comment in this figure is that the diazonal nerve of *Polypterus*, and hence its "coracoid" foramen, is not the homologue of the suprascapular nerve and notch in man, nor is either one the homologue

of the coracoid nerve and its foramen in modern Caudata, as discussed later.

PROTO-AMPHIBIAN STAGE

It may be assumed that under increasingly arid conditions such crossopts as were best fitted to withstand some desiccation were forced to spend more and more time out of water, travelling from one pool to another. After a long period of time the less adaptable sorts reinvaded the water while the others journeyed for a greater or lesser distance along the line of tetrapod ascent. The step from crossopt to amphibian was not a great one in many respects, but in others it required a profound modification of details, and the change from fin form to an effective terrestrial appendage must have taken a very long period of time.

In fish the fin action involves definite movement at the base, vaguer bending more distally, and spreading of the dermotrichia. Thus there is only one real joint. The journey toward tetrapods seems to have involved an increase of the cartilaginous shoulder girdle at the expense of the membranous elements, and elongation of the more strictly appendageous bones. At some stage between fish and tetrapods the rotation, comprising elevation of the preaxial fin border characteristic of the piscine stage, had to be corrected in order that the volar surface, formerly directed anterolaterally, could be placed flat upon the ground. That the change was in this direction rather than the reverse (placing the dorsum of the manus flat to the ground) is indicated by the subsequent arrangement of the brachial nerves.

Before an appendage can be used effectively for terrestrial progression it must develop more numerous joints than occur in fish, and it may be assumed that the ideal for the purpose comprises, in addition to the shoulder joint, a hinge at elbow

and another at wrist. To accomplish the latter the radius and ulna were obliged to have equal length, and the adjoining carpals, which occupy three different levels in *Sauripterus*, would then come to lie in a single transverse row (fig. 3, C). In this row there would then be an external (1_1) and internal (1_2) radiale, an internal (2_5) and external (3_5) ulnare, and a post-minimal element (3_6). If one then attempt to reconcile carpal conditions in *Eryops* in terms of *Sauripterus* and of the hypothetical stage B, it will be necessary to assume that all of the elements distal to 1_1 and 1_2 in B became a partial row of medialia, distal to the radius and proximal to the first three digits, and that in addition there was in this row a prepollical element (2_1). The only noteworthy feature of the most distal row of carpals in stage C is that in order to provide one for the fifth digit it appears necessary to assume that this was derived from the same level as the metacarpals of the remaining digits.

The exact manner in which the musculature of the piscine appendage adapted itself to the development of distinct segments and for the control of additional joints is not at all clearly indicated.

AMPHIBIA

Gregory (1915) has considered the cranial similarities among Paleozoic Amphibia to be sufficiently striking to indicate that the transformation from fishes into tetrapods occurred but once. The evidence certainly suggests that the immediate ancestry did not involve diverse groups of fishes, but it is not unlikely that a number of sorts of crossopts, with fin plan varying to some extent, reached the amphibian level.

Amphibia apparently arose in Devonian, if not in Silurian times. From the Carboniferous there are remains of labyrintho-

donts or stegocephalians, lepospondyls, and phyllospondyls. The most primitive Amphibia known, according to Noble (1931) and others, are the labyrinthodont Embolomeri. With similar affinities but representing successive evolutionary steps are the Rhachitomi and Stereospondyli, and it is with these that we are at present most concerned. To the Phyllospondyli belong the branchiosaurs and either they or their immediate ancestors are believed have given rise to modern Salientia and Caudata. The Lepospondyli are believed to have given rise to modern Gymnophiona or caecilians.

Although there are certain basic similarities, labyrinthodonts, modern Caudata, and modern Salientia are in many respects three very different groups. In the present state of our knowledge it may be assumed that Rhachitomi were reasonably close to, if not actually on, the line of ascent that led to mammals. Caudata and Salientia, however, have journeyed far in a tangential direction and it is not always easy to tell which of their resemblances are basic and which convergent. There are, however, surprisingly many points which they appear to have in common, though in modified form, with higher vertebrates. When discussing these it must, of course, be constantly borne in mind that all modern amphibians are highly specialized and reflect ancestral conditions only in the broadest respects.

In the present connection many specimens of *Necturus* were studied, certain details of *Triturus*, *Salamandra*, *Cryptobranchus*, *Amblystoma* and several other Caudata were investigated, and a number of *Rana catesbeiana* dissected. The latter were kindly furnished by the U. S. National Museum.

It is evident that in the most primitive type of tetrapod progression the limbs were not highly mobile but shared with

the body the function of locomotor apparatus. Independent movement of the limbs in the horizontal plane was at first restricted. They were elevated by a rocking movement of the girdle, involving simultaneous protraction of the member, this being accompanied by lateral flexion of the entire trunk. The intrinsic ventral muscles (flexors) then helped to anchor the animal and keep it from slipping backward while the body was bent contralaterally. Undoubtedly the body was first the primary locomotor apparatus on land but the limbs rapidly took over the major part of this function.

The most primitive tetrapod posture is frequently considered to be that in which the appendages sprawled at a right angle to the body axis, with digits directed



FIG. 5. TYPICAL URODELE PROGRESSION
(MODIFIED FROM BRAUS)

laterally. It appears that this is fundamentally incorrect. Such a posture is basic for the hind limbs, and for a long time they retain this position in their rôle of supporters for the rear end of the body. The fore limbs became the major locomotor apparatus as soon as they were sufficiently equipped to take over this function from the body. It is probable that at a very early date in their terrestrial phylogeny, if not from the first, they were held in such a posture that the radius was medial to the ulna while the digits were directed forward. This is the position best suited to enable the fore limbs to pull the animal forward. It means that from the very first the stimuli operating upon the musculature were different in the case of the two pairs of extremities, so that the elements of the proximal musculature of

the two pairs can not even be analogized, although there is so much basic similarity in the distal musculature. Furthermore, conditions in the shoulder girdle were complicated by the proximity of the head, gills, membranous girdle, and later by the ribs and sternum, none of which is comparable to any influence acting upon the pelvic girdle.

Skeleton

One can be sure that the appendageous equipment of the early Amphibia included a pectoral girdle that had larger endo- than exoskeletal elements, a humeral segment, elongated radius and ulna of equal length, flexible elbow and wrist joints, small carpal bones of basically asymmetrical pattern but under a stimulus for becoming symmetrical, and with probably five digits in addition to bordering carpal elements (prepollex and postminimus), the digits of unequal length with a phalangeal formula that should logically have been 2-3-4-5-4 (or 3).

The most primitive amphibian whose shoulder girdle is well known is the embolomorous genus *Eogyrinus* (fig. 1). It had a large clavicle and cleithrum, supracleithrum, and presumably post-temporal and interclavicle, as well as a large "scapulocoracoid." The Rhachitomi, as represented by *Eryops* and *Alegeinosaurus*, had lost the supracleithrum and its articulation with the head. The clavicle and cleithrum were reduced to narrow strips along the anterior border of the girdle, except that the cleithrum was expanded dorsally. The cartilaginous shoulder bone appears to have had but a single ossification, without sutures. Details of interest comprise the facts that the whole girdle sloped somewhat to the rear, the bone had developed forward, upward, and downward from the glenoid region, there was a supraglenoid buttress medially,

probably representing the originally more restricted part of the scapular portion, beneath which there appear to have been two foramina known as supraglenoid and coracoid. Piercing the arch was a small glenoid foramen. Gregory (1915) designates by the term metacoracoid the posterior part of the coracoid. It is entirely permissible, of course, to call this part of the coracoid a metacoracoid process, but it can not be regarded as a separate element, at least until it actually becomes so. It is clear from the fossils that attached to the more ventral part of the complex was an "epicoracoid" cartilage, which perhaps overlapped its antimeric at the midline. These details have been discussed by Cope, Miner, Romer and others.

An expanding girdle can encompass any nerve in its path, and similarly a contracting girdle can relinquish nerves. Hence almost nothing can be told about the homology of foramina in diverse sorts of fossils. All that appears positive is that such nerves as pass through foramina of the shoulder girdle are always from the ventral division of the plexus. In such fossil material as *Eryops* it appears unsafe to hazard an opinion whether the nerve piercing any particular foramen was the supra-scapular, coracoid, or one of the nerves to the brachial flexors; or two branches of the same nerve may have passed through as many foramina.

As indicated by the epicoracoid cartilages the two sides of the girdle in *Eryops* had developed some independence of action, and accompanying this was an increase in the mobility of the limbs, which had considerable movement but in a circumscribed pathway, in the horizontal as well as the vertical plane. This is shown by the conformation of the glenoid surface, usually termed screw-shaped, and by the strap-shaped humeral head. Watson (1918) believed that the humerus was in-

capable of any rotation on its long axis, but Miner (1925) has indicated that rotation to the extent of 90 degrees was possible. At any rate the shape of the glenoid suggests a very rolling gait, with much heaving about of the body.

The humerus of *Eryops* is extremely robust, with bold processes (fig. 2). It has the form of a tetrahedral prism, the proximal expansion being largely attributable to the shape of the articular surface, and the distal, to the great extent of the entepicondyle. The ventral part is greatly expanded, indicating strength of the muscles that advanced and depressed the arm, and similarly the entepicondyle is expanded for great leverage of the antibrachial flexors. Those interested in speculating upon the possible significance and relationship of the various details are referred to Miner's excellent discussions and illustrations. In a well selected series of fossil reptiles may be seen gradations of features that enable the investigator to interpret these in terms of living representatives with considerable accuracy. Such early amphibians as *Eryops*, however, exhibit details that do not occur in living forms, and it appears impossible to reconstruct the muscle attachments with desirable assurance.

The only things distinctive about the forearm bones of *Eryops* are the relatively great development of the olecranon and the distal expansion of the radius. These points, in connection with the great definition of the processes of the humerus, indicate a certain degree of specialization.

The plan upon which the carpus of *Eryops* was organized has already been discussed. Salient features consist of the facts that the bone occupying the position of the first metacarpal seems to have been originally a carpal element, while the carpal subtending the fifth digit was originally a metacarpal. The carpus was thus

essentially asymmetrical, the radial elements occupying a more distal position than the corresponding elements upon the ulnar side of the carpus.

In many respects conditions in modern Caudata constitute something very different from those in the Rhachitomi. Noble (1931) states that in the branchiosaurs there was no ossification of the cartilaginous girdle, but a narrow clavicle and cleithrum, as well as a small interclavicle, were present. It is likely that the basic ossification retained was in the paraglenoid region (Moodie, Gegenbaur, Miner), as a base for the divergence of three cartilaginous processes extending therefrom. But this proves that the branchiosaurs were already far on the road to modern amphibian conditions. It must constantly be borne in mind that the original amphibian condition was one in which both membranous and "cartilaginous" girdles were fused into a solid complex, and it was only later that there was recession in certain spots. Relinquishment of original connection with clavicle and interclavicle by the Caudata allowed those parts giving rise to critical muscles to become still more prominent, or hypertrophied, and permitted still further reduction of nonessential parts. It should be stressed, however, that these were not at first distinct elements but were processes of a single element, developing in accordance with muscle stress. Such processes in different animals can be homologized only providing they are associated with the same muscles, a difficult matter to prove in many fossils.

In modern Caudata there are usually three such processes, all well defined, developed by the elevator (largely), protractor, and depressor muscles of the brachium. The terms scapula, pre- or procoracoid, and coracoid for them have become firmly established without any regard to the mus-

culature involved, but the second is an unfortunate term, for it really is a proscapular process and will be so termed by me hereafter. Suprascapula is the designation employed for the cartilage dorsal to the scapular ossification, and epicoracoid for the cartilage which was situated between the coracoid and midventral line in some of the labyrinthodonts. There is some difference in the application of the above terms, however. Thus Case, Williston and others have used epicoracoid to designate the unossified element occurring anterior to the two coracoids in some reptiles. At best it is frequently difficult to draw a hard and fast line between procoracoid and epicoracoid.

It will be realized that ossification of the urodele girdle as now found is not a case of bone forming from one center and expanding, but the reverse. The modern condition has been brought about by the restriction of the ossification of a once uniformly bony girdle. The bony boundaries have retreated as aquatic specialization dictated, to a greater or lesser extent, and in different situations in diverse sorts. Hence there is much variation in this respect as might be expected, to such a degree that it is difficult to present generalities. Perhaps most frequently there is a single ossification of the scapular constriction, but this may extend to include the paraglenoid region (*Salamandra*), or there may be a separate coracoid bone (*Siren*, Parker; *Pseudobranchius*, Noble). In *Molge* and *Amblystoma* the ossification may even extend to the procoracoid base. All have lost any evidence of a membranous girdle. The reason for this is obscure, although it may be correlated with the reduction in ossification of the cartilaginous girdle because of a weakening of the muscle attachments brought about during an aquatic life.

The coracoid is usually pierced by the

coracoid nerve; hence this is a true coracoid foramen and not the homologue of the diazonal foramen of *Polypterus*, which transmits another nerve. Parker (1868) has stated that in *Salamandra* and *Triton* the nerve passes over the procoracoid-coracoid notch, but in the former genus I found it piercing.

In at least many Caudata there is an anterior expansion of the humeral head continuous with a well defined deltoid process farther distally. The entepicondyle is likewise better defined than the ectepicondyle, and the olecranon also is well developed. On the whole, however, the bones are weak, and the insertion of many of the muscles upon the capsule of the joints rather than upon the bone proper.

The carpus of urodeles is quite specialized, the tendency being toward the fusion or elimination of some of the elements.

Conditions in the Salientia are not of paramount importance to the present study; yet they should be briefly discussed for the sake of completeness. Like the Caudata this group also has, typically, an ossified scapula with cartilaginous suprascapula, although there is frequently calcification of the dorsal part of this (Noble). Upon the anterior border is usually a small cleithrum (Schmalhausen, 1917; Engler, 1929). The rest of the girdle is quite variable but most often there is an ossified coracoid with restricted middle, separated from a slender, bony clavicle and cartilaginous or ossified procoracoid by a fenestration or "obturator foramen." Both clavicle and procoracoid are occasionally absent (Brevicipitidae). At times the three elements are all fused (*Dendrobates*). The procoracoid may be said usually to be bounded by the scapula, coracoid and clavicle, with an acromial process projecting forward. In large, old specimens of *Rana* ossification is extensive and at the medial base of the acromion is a large

"supraglenoid" foramen, which transmits minor nerves and blood vessels to the joint. This is located anterior to a prominent ridge, probably representing the "supraglenoid buttress." The procoracoid frequently extends medially, posterior to but attached to the clavicle to join the epicoracoid, or even to fill the space between coracoid and clavicle (*Xenopus*).

The case of the epicoracoid presents an interesting question. The basic, proto-amphibian condition was undoubtedly one in which there was solid articulation of the two sides of the girdle. It appears that there was later relinquishment of this anchorage, for independent movement of the two halves of the girdle, by means of a recession of the ossified part of the coracoids from the midline and an overlapping of the cartilaginous parts (epicoracoids). In the Salientia the latter is considered (Noble) to be the primitive condition, not vice versa (Huntington, 1918), while in some more specialized sorts there is a change from this arciferal type to a firmisternal condition, in which the episternal cartilages are fused at the midline. It appears necessary to assume that a similar course was followed by the amphibian, or at least reptilian, ancestors of the Mammalia in order that the coracoid musculature could settle down on the midline of the trunk. When this had occurred there was no longer need or reason for extensive coracoids and they could degenerate to mere processes for the origin of tendons of such brachial muscles as might later be concerned therewith.

There has been considerable argument at one time or another over the question whether the "obturator foramen" of Salientia represents the coracoid foramen or the coracoid-procoracoid notch of Caudata. It seems evident that it represents both. In terms of the tailed amphibians it may be said that the anterior border of

the coracoid receded until the coracoid nerve was included in the notch, and that in Salientia the precoracoid and epicoracoid cartilages then surrounded the space.

In such a form as *Rana catesbiana* the humerus is quite similar to that of Caudata, except for being considerably more robust. Its main crest, divided into a proximal and a more distal prominence, seems largely concerned with the pectoralis, but latissimus, dorsal scapular, and coracohumeral muscles all contribute, while the deltoid has but little to do with it. Upon the medial aspect of the humerus there is a ridge marking the insertion of the coracobrachial muscle divisions.

No modern amphibian has more than four digits in the manus. Schmalhausen (1917) demonstrated additional elements in the larval *Bombina*, but it is doubtful if these are more than carpal elements.

Nerves

As previously discussed, and as will be amplified later, the nerves are considered always to offer reliable information regarding the relationship of muscles. The information which they furnish must be used with intelligence, however, for conditions are often obscured. Nerves are subject to certain minor, or even major (facial and trigeminal fields) changes, which would be clear if one could examine the complete phylogenetic record. One should be careful not to make such mistakes as to assume that the first nerve to split off from the plexus anteriorly must be the same in all cases, as has frequently been done.

As compared with fish the Amphibia exhibit a bare beginning of the posterior migration of the brachial plexus that is farther advanced in reptiles and mammals. Basically the plexus may be said to be formed by three cords, as in *Polypterus*, these coming in Caudata from spinal

nerves III, IV, and V. In the latter the middle one or fourth is usually more robust than the other two combined. The second nerve may also contribute but it is probable that this usually carries only hypobranchial fibers. At least when such an anastomosis is present in *Necturus* there appears always to be a hypobranchial branch given off from the combined nn. II and III as well as one from n. II alone. Rarely there may be a similar contribution to the plexus from VI (*Megalobatrachus*, Fürbringer, 1879), the derivation then being from five nerves, simulating the condition in mammals. But still the two upper nerves fuse, as do the two lower, forming three cords.

Fundamentally, then, it is believed that the tetrapod plexus is derived from three cords, coming from a number of nerves varying from three to five. The major alignment is next into dorsal and ventral divisions, supplying respectively the original extensor and flexor musculature. In all tetrapods these are relatively easy of determination. Fundamentally it should probably be considered that the dorsal division of the appendageous musculature, and hence the nerves, is separable into an extrinsic, suprazonal (or supra-cleithral) group (serrati), another group concerned with the shoulder, a third brachio-antibrachial group for moving the forearm, and of course elements for podial action. From each of these, particularly the second, certain subgroups later take form, their nerves exhibiting a greater or lesser degree of distinctiveness. In this category fall the nerves to the latissimus, dorsalis scapulae, and proscapulohumeral divisions.

Concerning the nerves of such subgroups of muscles there is often a definite trend, which might well be dignified by the term law. This is to the effect that if some particular division of one subgroup be so

situated as regularly to act with another subgroup, its nerve will exhibit a tendency to align itself with the innervation of that subgroup, if no intervening obstacle impose. Hence the innervation, particularly in one of the higher vertebrates, is not always precisely diagnostic of the origin of a muscle, or rather the facts may be thus obscured. In line with this reasoning is the apparent fact that high spe-

A discussion of the brachial nerves of the Caudata, as typified by *Necturus*, may be presented as follows:

N. vago-accessorius, so-called, is a small branch diverging from the vagus and innervating the m. trapezius.

Nn. hypobranchiales, from either sp. n. II alone, or when there is anastomosis of this nerve with III, then a second branch from below their junction, to the hypo-

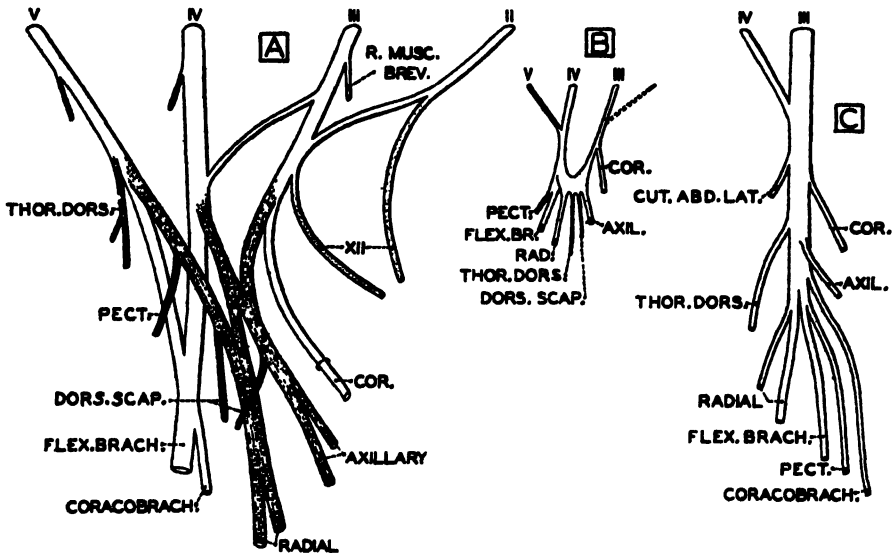


FIG. 6. (A) LATERAL VIEW OF COMPOSITE, RIGHT BRACHIAL PLEXUS OF *NECTURUS*, SOMEWHAT IDEALIZED, PROXIMAL PART SHORTENED, DISTAL PART ELONGATED; DORSAL ELEMENTS SHADED, HYPOBRANCHIAL (XII) ELEMENTS STIPPLED. (B) AN EXTREMELY COMPACT TYPE OF BRACHIAL PLEXUS OF *NECTURUS*. (C) LATERAL VIEW OF RIGHT BRACHIAL PLEXUS OF *RANA*; PROXIMAL PART SHORTENED

cialization restricting the diversity of arm movements will tend to result in a greater homogeneity of the entire plexus (*Salientia*).

Basically the nerves to the extrinsic muscles of the limb are given off from cords before the plexus proper is reached, as noted by Detwiler (1920). Thus there are fine twigs from the nerve roots supplying the slips of the serrati, including levator scapulae, and subsequent branches to the latissimus and pectoralis, while the trapezius and omohyoid have other innervation.

branchial musculature, including the three slips connected with the girdle.

Dorsal (extensor) division

Suprazonal group

Rami musculares breves, from all brachial roots, supplying slips of the serratus and levator scapulae.

Shoulder group

N. thoracodorsalis (*latissimus dorsi*) usually diverges from n. V before the latter reaches the plexus, but at times it comes from the plexus direct. It supplies the

mm. latissimus dorsi and usually the dorsi-triceps. With it is sometimes associated a small nerve to the posterior part of the m. dorsalis scapulae.

N. axillaris communis supplies the rest of the dorsal muscles whose chief bulk lies proximal to the shoulder joint. It might with equal propriety be considered as the upper division of the radial. In some urodele plexuses it is totally distinct from the latter, and in such case is derived from nn. III and IV. It supplies the mm. dorsalis scapulae, scapulohumeralis brevis, and proscapulohumerales longus and brevis. At times twigs to some of these muscles, particularly the first, diverge above the point where the main axillary separates. In some cases it also conducts twigs to some of the triceps divisions.

Brachio-antibrachial group

N. radialis (brachialis longus superior) is derived from nn. IV and V, and possibly at times from III as well. It follows the usual course, piercing the triceps, but is variable in its branches. Not infrequently there is a preaxial branch extending down the radial side of the antibrachium, and a postaxial branch down the ulnar side, the latter unrepresented in mammals as a definite entity. This, where it occurs, appears to be more concerned with the brachial extensors and the other with the antibrachial. Occasionally the two branches have separate origin from the plexus. The triceps may be said to be so innervated, usually with the exception of the dorsi-triceps element. A second branch to the dorsalis scapulae often diverges from the n. V contribution to the radial. This appears to occur only where the other nerve to this muscle comes from IV alone and has no especial significance.

Ventral (flexor) division

Shoulder group

Here belongs a discussion of the n. suprascapularis of mammals, which is un-

represented as such in modern Amphibia, for there is no brachial nerve passing anterior to the scapula. Authors have frequently implied, if not actually stated, an opinion that the anterior part of the innervation of the m. dorsalis scapulae has in mammals changed its course and position from posterior to the scapula to one carrying it anterior thereto. This is not sound morphology. If such a change took place it would have to be gradual, involving migration of a foramen transmitting the nerve, from one border of the scapula to the other, and there is no slightest evidence that this ever occurred. Nerve pathways are conservative and when a muscle shifts sideways it drags its nerve along, contorting the old pathway, perhaps, but not taking short cuts. Hence this possibility must be ruled out.

It has never been determined whether the suprascapular nerve of mammals belongs with the dorsal or ventral division of the plexus. In man Kerr (1918) found that it may come from either. Some anatomical text books incline to one view and others to the opposite. I have had the question constantly in mind during dissections but have been able to arrive at no conclusion. There is this to be considered, however; the nerve is variable in this respect, hence it is permissible to entertain the theory that it is in course of change. Its musculature is aligned with the dorsal muscles; hence if it were originally a dorsal group the nerve would have no occasion to alter its relationship. If it were originally a ventral muscle group its nerve might very well exhibit this tendency for allocation with the adopted dorsal division. Hence this evidence suggests, but does not prove, a ventral derivation.

With the above in mind there appear to be only three possibilities at all tenable for consideration: a) that the suprascapular element, originally present in early ancestral tetrapods, has been lost by modern Amphibia, and Reptilia (apparently); b)

that it was derived from the axillary matrix; and c) that it was derived from the coracoid complex.

a) It is tempting to consider that during the "unrotation" of the crossopt fin the more dorsal and proximal part of the flexor (lateral) musculature was left in a position more dorsal than the remainder of the flexors, and thus excellently situated for ultimately becoming the suprascapular group. The fact that the group is absent in living reptiles and amphibians is no disproof of the theory for they may represent lines that early lost it. If this were so, however, the nerve would have passed between membranous girdle and scapula, leaving in fossils of early tetrapods an unmistakable scapula foramen. There is no record of any such foramen and the theory therefore appears unsound.

b) Derivation from the axillary matrix would mean not only that the suprascapular musculature belonged originally to the dorsal division, but that it has migrated anteriorly from the axillary region along the medial surface of the scapula and then over its dorsal border to the present mammalian position, as indicated by present innervation. This is not impossible, morphologically speaking, for a similar situation is found in the facial field, and its nerve would be expected eventually to diverge from the plexus higher up so that it might well simulate the position of the suprascapular nerve. But it is unlikely that such a roundabout course of migration would be adopted when a more direct one was available (but was not followed).

c) The essential features of suprascapular muscle derivation from the coracoid matrix have been advanced by Romer (1922), and at present this appears to be the most attractive theory for tentative adoption. At first glance it may not seem likely, but further consideration, in connection with the situation in reptiles es-

pecially, is more convincing. It would involve dorsal migration of the origin of the most dorsocranial division of the coracoid musculature, passing medial to the clavicle and acromion so as to invade the anterior base of the scapula; hence beneath a part of the deltoid. Its nerve would then logically tend to diverge from the plexus above the original n. coracoideus, and after long association with dorsal elements, might well exhibit a definite trend toward allocation with that division, as it now seems to do. Further discussion of the problem will be deferred for the contribution of this series concerning reptiles.

N. pectoralis appears to have the same relationship to the n. coracoideus as n. thoracodorsalis has to the axillary complex. It is always very distinct and arises from n. V, usually above the plexus but at times as an upper branch from the common flexor nerve. It supplies the true pectoral musculature.

N. coracoideus (supracoracoideus) arises from n. III, usually above the plexus, and is a very distinct entity. It pierces the coracoid cartilage by one or more foramina (said by Parker (1868) to pass anterior to the coracoid in *Salamandra* and *Triton*, but I found it piercing in the former genus) and supplies the two divisions of the coracohumeral musculature.

Brachio-antibrachial group

N. coracobrachialis. This nerve may be considered as consecutive with the n. coracoideus but it could not recently have split off that element, else it would pass through the coracoid foramen. It arises probably from n. IV and perhaps at times from III as well, separates above the axillary region and supplies mm. coracobrachialis and gleno-antibrachialis.

N. flexor brachii (brachialis longus inferior) arises from nn. IV and V. It

passes in the brachium deep to the m. gleno-antibrachialis, and after giving off a twig to the m. brachialis, divides into a component corresponding to r. cutaneus antibrachii lateralis n. musculocutaneus of mammals, and into median and ulnar branches which pass to the forearm.

In the Salientia the brachial plexus is secondarily much simplified, but complicated for the student. There is a tendency for the restriction of the brachial area of the spinal cord which is in line with similar restrictions posteriorward, at least one of the contributing causes for the condition probably being the fact that anurans do not habitually indulge in a great variety of movements.

So far as I know no member of the Salientia has more than three nerves contributing to its brachial plexus, while that from the anteriormost may either carry hypobranchial fibers, be very small indeed, or not join at all. The second (n. III) is enormous, and the third (n. IV) very small. Hence, not only is the brachial center one segment farther forward in Salientia than Caudata, but it is more concentrated in the former. Junction of the two (or three) nerves occurs very high and there is then a long, stout cord. Even after many of the branches separate they are contained for a space in a common sheath.

A discussion of the brachial nerves of the Salientia, as typified by *Rana catesbeiana*, may be presented as follows:

With discrimination dorsal and ventral nerves, but disposed more in an anterior (flexor) and posterior (extensor) manner, may be distinguished.

N. vago-accessory, so-called, is a branch of the vagus innervating both mm. trapezius and interscapularis.

N. hypobranchialis, from sp. n. II, sends a branch to the muscle termed provisionally omohyoid.

N. cutaneous abdominis lateralis is mentioned because of its prominence. It is evidently derived from n. IV alone and is given off the main brachial trunk posteriorward to the side of the body.

Dorsal (extensor) division

Suprazonal group

Rami musculares breves, from II, III and IV, innervate the eight slips of the serratus matrix, including the two rhomboid and two levator scapulae elements.

Shoulder group

N. thoracodorsalis, like all subsequent nerves, is given off the main trunk and is the highest of the extensors. It innervates the latissimus but usually has also a branch near its base, the ramus posterior dorsalis scapulae, to that muscle. The association of this ramus with the base of the nerve may have but little significance.

N. axillaris usually comes off the cord next. It supplies the superficial and deep parts of the deltoid, and usually the anterior innervation of the dorsalis scapulae, although the latter branch not infrequently leaves the trunk independently and just above the axillary.

Brachio-antibrachial group

N. radialis may be said to have two divisions, one mostly to the brachial and the other to the antibrachial flexors. The former may occur as several separate twigs.

Ventral (flexor) division

Shoulder group

As in the Caudata the suprascapular nerve as such is absent in the Salientia.

N. pectoralis comes off at the base of the brachial flexor nerve, with which it is doubtless secondarily associated because the action of its muscles is apparently so intimately related to that concerned with brachial flexion. It accompanies the bra-

chial flexor nerve beneath the origin of the caput scapulare tricipitis before it innervates the three (really four) divisions of the true pectoral musculature.

N. coracoidens is the first ventral nerve given off the brachial trunk. It passes through the "obturator" foramen and supplies the coracoradial and the two parts of the coracohumeral musculature.

Brachio-antibrachial group

N. coracobrachialis appears to lack some of the elements of this nerve in Caudata. It frequently diverges from the brachial trunk above the *n. pectoralis* and supplies the three divisions of the *mm. coracobrachiales*.

N. flexor brachii diverges from the *n. radialis* before the capsule of the shoulder is reached and passes just deep to the origin of the caput scapulare *m. tricipitis*. At the anterior border of this muscle it becomes entirely superficial and so continues down the front of the brachium until it disappears between the extensor and flexor groups of the antibrachium, but not having a branch characteristic of a *n. ulnaris*. Its superficial course in the upper arm is attributable to the fact that the coracobrachial musculature is confined to the proximal end of the brachium.

Muscles

The muscles of the appendages are arranged in definite groups. Topography is, of course, often of considerable value in the identification of some individual units, but it is often extremely misleading. Not only may the situations be different, but also muscle attachments can alter greatly by initial retreat, by lateral shift, and finally by secondary advance, or in other ways, so that the only trustworthy criterion is the innervation. Even the latter may tend to lead one astray because of the fact that some units of one group may act

with a second, and other units with a third group of muscles, the respective nerves then tending to align themselves with those of the adopted units. Conditions must then be interpreted in terms of phylogeny.

As already indicated in the discussion of nerves, different groups of muscles have different values and any exact arrangement must include many points that are subject to arbitrary decision. Thus it is a matter of individual opinion whether one considers that the *dorsalis scapulae* and *procoracohumeralis* belong to one group or two.

The conformation of the musculature during vertebrate phylogeny indicates a trend toward certain, definite patterns characteristic of particular stages. That found in modern Amphibia may not represent an ideal, but is probably about as close to it as the limitations of the organism have permitted. The extrinsic system for operation of the girdle appears to have comprised a protractor (*levator scapulae*) and retractor of the dorsal part, both derived from serratus slips. The retractor portion later changed to elevator (*rhomboid*) and depressor (*true serratus*). Elevation and protraction of the central part of the girdle were effected by the *trapezius*, and protraction more ventrally by *hypobranchial* slips. These, of course, attached originally to membranous components of the girdle. Retraction with elevation of the glenoid region was effected by the *latissimus*, and retraction with depression by the pectoral musculature, both probably inserting fundamentally upon the capsule of the joint rather than any particular bone. There are thus basically five extrinsic groups of muscles operating upon the shoulder girdle, the posterior two being dual-purpose groups, acting upon both girdle and brachium.

Modern urodeles have certainly had

sufficient time to adapt their musculature thoroughly to an aquatic habitat, and they illustrate an arrangement for control of the brachium that may be considered as fairly ideal for their type of life. This comprises five groups of muscles for moving the arm in as many directions, as already pointed out by Rylkoff (1924), consisting of scapular musculature, with action just cranial of dorsal; procoracohumeral group, cranialward; coracoid group, just cranial of ventral; pectoralis, caudoventralward; and latissimus, caudo-dorsalward. It is probable that the original musculature of the first three of these groups had origin also from the membranous components of the girdle, while the last two are, or at least early became, extrinsic muscles probably acting largely on the capsule of the joint as already mentioned. Several of these groups either had, or easily developed, shorter slips to effect a greater variety of brachial movements.

It is felt that in modern amphibians the brachium is situated in a somewhat anomalous position, for it furnishes a common attachment for the longer muscles of the shoulder and the muscles passing to the forearm. A higher plan of extensor (triceps) control has begun to be well organized, but the brachial flexors exhibit poor organization. Perhaps the movements needed have been too simple to furnish an adequate stimulus, or the original equipment provided was difficult to alter.

There is a great deal of well illustrated literature giving in greater or lesser detail particulars regarding the anterior limb musculature of modern Amphibia, so that the topography is thoroughly known. Some of these contributions carefully describe the peripheral nerves as well. The older of them are usually quite worthless from a morphological viewpoint because so little was known regarding nerve-

muscle relationship at the time they were written. Even such excellent reports as that of Wilder (1912) are of no help in morphological determinations because the nerves are ignored.

A second type of myological publication is that wherein the musculature of fossils is reconstructed. An outstanding instance is the report of Miner (1925), a truly masterful presentation of his subject. His discussions are invaluable, and yet it is the individual opinion of the present author that but little reliance can be placed upon any restoration of muscles of fossils, no matter how expertly done, because of the impossibility of accuracy in the more detailed points, which are usually the most important ones. In fine, it is considered that but little can be told of the more significant details of the muscular conditions in *Eryops*, and that most of this is uncertain. Only broad generalities can be presented with any confidence.

As already stated some of the muscles of Caudata and Salientia can with certainty be homologized with those of mammals. Others can be so treated with considerable probability, while in a few cases there is more uncertainty. They both arise from the same matrix, however, and although very possibly they might not both have come from precisely the same part of the matrix, they may properly be called equal, *providing* any existing uncertainty is clearly stated. The muscular conditions of *Necturus* can be compared with those in mammals with more assurance than *Necturus* can be compared with *Rana*. In view of the high specialization of the Caudata it is really astonishing that one can homologize the more significant details of their musculature with those of mammals so satisfactorily.

Branchiomic division

M. trapezius (cucullaris) very clearly represents the posteriormost element of

the original gill arch musculature. Because of the facts that branchiomic slips to the membranous girdle in fish are variable and that other slips with myomeric derivation in this group have at times been termed trapezius in spite of somatic innervation, this detail reaches the amphibian stage with more uncertainty attached to it than the facts warrant. In modern Amphibia it appears always to be uncomplicated by division and a sternocleidomastoid element is consistently lacking. The trapezius arises either from the superficial fascia between head and girdle (numerous Caudata), or has a tendency to shift to the head (Salientia). In *Necturus* it is quite broad, and in *Rana* narrow but thick. In the former it inserts at the anterior base of the scapula and in the latter upon the dorsal base of the acromion—especially the same situation. There can be little doubt but that the insertion of this muscle was basically upon the cleithrum, perhaps quite broadly so, as believed by Romer and Miner, and this may well have included a part of the clavicle. As it is now found in amphibians it has evidently shifted to the border of the scapula and relinquished the more dorsal part of its attachment, as well as any connection with the clavicle, as the cleithrum became severely restricted or disappeared. In its rôle of elevator and protractor of the shoulder it is one of the most important and constantly used appendicular muscles of tetrapods in general.

Miner described for *Megalobatrachus* a broad levator scapulae innervated from both spinal and vago-accessory sources. It is clear that the dorsal part of this sheet was narrow with attachment well away from the scapula border, and constituted a perfectly normal levator scapulae. Extending ventrally from this was a relatively broad sheet with origin from the pharyngeal wall and aponeurotic inser-

tion upon the scapula border. It seems that this was the part with visceral innervation. The conclusion which this circumstance led him to adopt was that the history of the levator scapulae is similar to that of the trapezius. The suggestion was offered that this represents the deeper portion of branchiomic slips found in Holocephali and Selachi; that the trapezius and levator scapula represent in urodeles the remainder of the branchiomic system and as in the case of the trapezius there has been a taking over of the levator scapulae by the somatic system, as yet uncompleted in *Megalobatrachus*, the stage in the latter being comparable to the stage of the trapezius in higher forms.

The condition of this sheet as reported by Miner is unique among vertebrates. Not only has a broad levator scapulae partially innervated by a visceral nerve never been described in other urodeles, but it was not found in *Megalobatrachus* by Humphry (1872) and Osawa (1902), and it is not the case in the *Cryptobranchus* which I have dissected. Certainly there are insufficient grounds for considering that the levator scapulae was originally a derivative of the gill arch musculature, or that Miner's levator scapulae is not a compound element. The logical conclusion is that a vagrant visceral slip, comparable with the interscapularis of anurans, has secondarily become associated, where such a condition exists, with the myomeric levator scapulae.

M. interscapularis is found only in the Salientia. It is fan-shaped, arising from the more anterior part of the medial surface of the suprascapular cartilage and converging, in the region of the supraglenoid buttress, to an insertion upon the base of the scapula, caudally adjoining the trapezius. Its function is to bend the dorsal part of the girdle in a medial direction, but the importance and degree of such

movement appears to one as insufficient to account for its strength. Its position suggests that it may have been derived from the settling down upon the suprascapula of a part of the trapezius; but it is better to consider it merely as a division of the

Hypobranchial division

This is quite variable, and it is felt that conditions in amphibians should not be compared to those in mammals with too much exactitude.

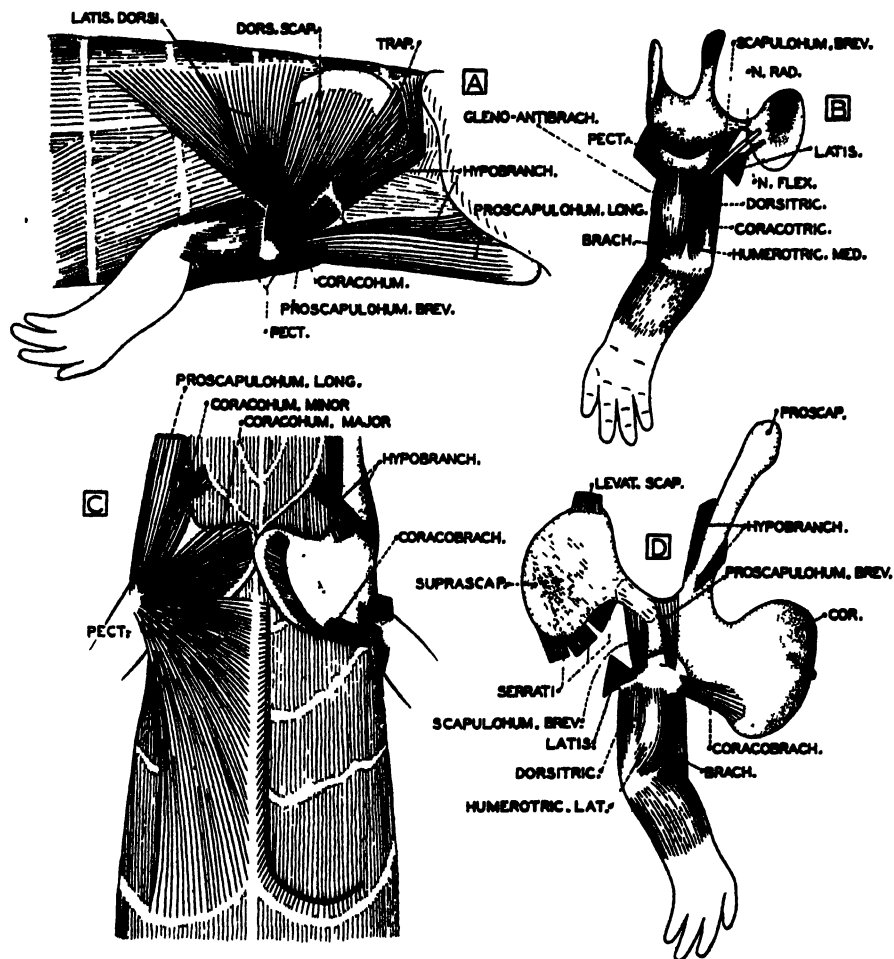


FIG. 7. THE SHOULDER REGION OF *NECTURUS*

(A) Right lateral view, (B) Medial details of right brachium and of shoulder girdle; (C) Ventral view; (D) lateral details of right brachium and deeper musculature of the lateral girdle.

branchiomic system, without more precise commitment.

Innervation is by a separate twig of the vago-accessory branch supplying the trapezius.

M. omobryoides may or may not be equal to the muscle of the same name in mammals. In *Necturus* it arises from the interbranchial fascia and inserts upon the border of the scapuloprosapular notch. In

Megalobatrachus it is broader and joins the sternohyoid (Miner). In *Rana* it arises from the hyoid and passes medial to the girdle and the m. interscapularis to an insertion upon the posterior border of the scapular base. It appears that originally this may have been the chief clavicular muscle for protraction of the girdle, as stated by Miner, and that later it became identified with the scapula. This theory is reached by inference, however, and not by direct evidence, except that offered by *Sphenodon*.

In *Necturus* there are two additional hypobranchial slips to the girdle, termed by Wilder rectus superficialis hypobranchialis posterior. They arise from the myosepta of the common hypobranchial mass and insert upon the proscapular process near its base, one over the superior and the other over the inferior border of the cartilage. In *Megalobatrachus* two analogous slips are termed sternohyoideus by Miner. They insert upon the scapular border and sternum respectively. In *Rana* posterior attachment is to the sternal cartilage. I prefer not to offer a commitment as to whether these are homologous in Caudata and Salientia, calling them merely hypobranchial slips.

Innervation is by sp. nn. II and III in Caudata; evidently by n. II alone in Salientia.

Dorsal (extensor) division

Suprazonal (or serratus) matrix

This may be divided into levator scapulae, rhomboid, and true serratus slips, and there appears to be no doubt but that all arose from a common group of several slips arising from the myosepta and most probably inserting originally on the dorsal part of the cleithrum, or even supracleithrum, secondarily becoming associated with the suprascapula, and the scapula also in Salientia. The original inclina-

tion it is impossible to tell, but the anteriormost, becoming the levator scapulae, probably extended toward the head at a very early date, while the others became disposed at various angles.

In *Necturus* the arrangement is relatively simple. There is a single levator scapulae arising by the finest of thread-like tendons (as in many Caudata) from the medial part of the occipital region, and inserting upon the cranial angle of the suprascapular cartilage. Rhomboid divisions are lacking. There are three serrati proper arising from as many myosepta and having dorsal and cranial inclination, so that they pull the scapula backward and downward.

Megalobatrachus (Miner) and *Cryptobranchus* present a condition which is probably somewhat more specialized in that the direction is more strictly fore and aft. The levator scapulae is essentially the same as in *Necturus*, except for its association with a branchiomeric unit in Miner's *Megalobatrachus*. The serratus occurs in five slips (number subject to some variation) so disposed as all to pull the scapula backward. Osawa calls the group as a whole thoraciscapularis.

In *Rana* this group has become highly specialized. There are two divisions of levator scapulae from the posterior part of the cranium to the medial part of the suprascapular angle and the posterior part of the inferior scapula respectively. Two rhomboid divisions have begun to differentiate from the group, the first of which is associated with the levator scapulae superior, and the second, or posterior, with origin from the midline, inserts by a common raphe with the most dorsal of the serrati. The latter are four in number, three with the usual attachments and the fourth inserting far down upon the posterior base of the scapula. It is relatively powerful. It may well be that the chief use of this muscle group in the frogs is

for easing the shock of landing after a long hop.

Innervation of the levator scapulae is by sp. n. II (at times possibly by n. III as well) in Salientia; the remainder of the complex by nn. III, IV and V in *Necturus*, and by nn. III and IV in *Rana*.

Thoracodorsal (latissimus) matrix

M. latissimus dorsi is always clearly recognizable as such throughout the tetrapods, hence for convenience it is considered as constituting a separate group, although its relationship to the dorsal scapular muscle is so close that this is a purely arbitrary course. Unlike the other intrinsic muscles so far mentioned it is uncertain whether this element primarily was at all concerned with the membranous girdle. Of less importance is argument whether it had extrinsic or intrinsic origin. This, after all, is an academic question, for every muscle of the appendage is believed originally to have been derived from the trunk musculature. At least it must have diverged from the axillary matrix at a very early date, and it is highly probable that the original insertion was upon the capsule of the joint, with slight encroachment upon the scapula or (and) humerus as conditions dictated. Its early definition was doubtless stimulated by the need for a muscle to retract, while elevating, the shoulder.

In amphibia this muscle may be broad or narrow, but it always has origin from the dorsal fascia. Insertion in Caudata should probably be considered as partly upon the capsule of the joint, and partly upon a raphe common to this muscle and the dorsitriceps, although conditions may vary to some extent within the order. In *Rana* insertion is by a stout tendon shared with the dorsal scapular muscle and inserting upon the pectoral ridge of the humerus.

Innervation of the latissimus and usually dorsitriceps in Caudata is by a separate branch from n. V, but at times the latter muscle is supplied by way of the radial. The latissimus in Salientia has similar innervation.

Axillary matrix

This group comprises the dorsal elements which arise from the girdle and insert upon the humerus. It includes the lateral scapular and proscapulohumeral divisions. Relationship of the first is rather intimately concerned with the latissimus, while one can be sure that the second originated from the common extensor matrix of the shoulder. The rank which one accords to the separate components is thus an arbitrary decision.

M. dorsalis scapulae arises in Caudata over a variable extent of the suprascapular cartilage and in *Necturus* it converges to a narrow insertion upon the anterior (ventral) process of the proximal humerus. In *Rana* it is a powerful muscle from the basal half of the suprascapula, developing a strong tendon which joins with the latissimus tendon to insert upon the pectoral ridge of the humerus. The anterior part may be partially separable.

It is likely, as Watson and Miner have pointed out, that this was at one time *the* lateral muscle passing from cleithrum to humerus, and as the former bone became restricted the muscle settled down upon the expanding suprascapula and scapula. It is quite closely related to the latissimus, and particularly to the proscapulohumeral subgroup. Throughout the literature it is rather consistently considered as a part of the deltoid, but it does not enter into the composition of the deltoid of mammals. It is also evident that it has nothing to do with the true suprascapular musculature of mammals. As the latter group is lacking in modern Amphibia the

dorsalis scapulae has spread over the whole extent of the dorsal girdle component. At a later tetrapod stage the suprascapular musculature increased at the expense of the dorsalis scapulae, crowding the latter to the posterior border of the girdle, where

how the two muscles have been separated by the long head of the triceps, and it becomes apparent that the dorsalis scapulae is the forerunner of the teres minor. The innervation also bears this out. Furthermore, this is the only muscle of

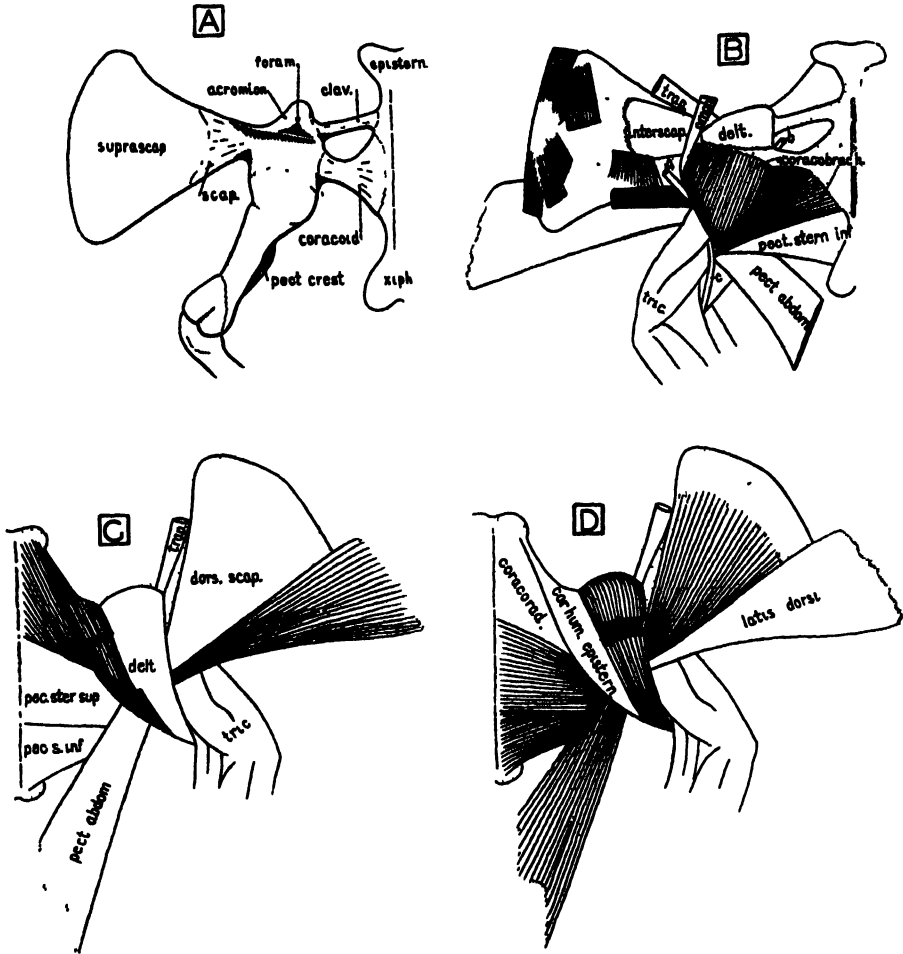


FIG. 8. DETAILS OF THE LEFT SHOULDER OF *RANA CATESBEIANA*

(A) Medial view of skeletal elements; (B) Medial view of musculature, (C) and (D) Lateral view of musculature. Muscles depicted, shaded or unshaded by phylogenetic groups.

it becomes in mammals one of the teres divisions. In *Rana* the dorsalis scapulae appears to have all the qualifications of a teres major, inserting, as it does, with the latissimus. In *Necturus* one is not so sure, while in reptiles and mammals one can see

cold blooded tetrapods that could become the teres minor without a great amount of alteration of its insertion.

M. scapulohumeralis brevis. This apparently is not the scapulohumeralis muscle of Miner, but his subcoracoscapularis, a

term which I regard as misleading because in amphibians it has nothing to do with the subcoracoid area. In *Necturus* it is located laterally adjacent to the brachial nerves, with origin from the caudal border of the scapular base, and rather lengthy insertion upon the shaft of the humerus. In *Rana* there is a very short, small muscle evidently representing this element arising by a tendon from the posterior border of the scapular base and inserting fleshily upon the adjoining part of the neck of the humerus. It is hidden by the deltoideus profundus and dorsalis scapulae, and is not illustrated. This slip and the scapulohumeralis brevis offer certain difficulties which will be discussed under the heading of the latter muscle. Suffice it here to say that the former element appears to contribute to the subscapularis of mammals.

M. proscapulohumeralis longus (procoracohumeralis, deltoid Romer, deltoideus clavicularis Miner). This division is at times termed procoracohumeralis, but as it is a dorsal muscle this is a misnomer. In *Necturus* it arises from the lateral surface of the distal half of the proscapular process except near the tip, and inserts upon the anterior (ventral) process of the proximal humerus. It is perfectly distinct from the coracoid group, but in other forms, such as *Salamandra*, the two give the superficial appearance of being a single sheet.

In *Rana* I have termed this division deltoideus superficialis. It is much specialized, as it has invaded the medial aspect of the girdle, with origin really from the medial base of the coracoid. Thence it passes over the acromion, to which there is extensive attachment, and insertion is upon the medial epicondyle of the humerus, a further specialization.

There is essential agreement among authors that this represents a part of the

deltoid, and to my mind it is the sole representative. Basically with origin from the clavicle it has settled down upon the procoracoid as the clavicle disappeared in the Caudata, and has stimulated that cartilaginous process to great extension in some forms. In *Rana* it has left the clavicle, evidently for a more favorable angle of action from the acromion. It has undoubtedly been instrumental in the definition of this process, but has secured greater length by encroachment upon the medial side of the girdle than the acromion has perhaps been capable of effecting, and by extension down the arm.

M. proscapulohumeralis brevis (procoracohumeralis, scapulohumeralis anterior). Miner found this deep division well developed in *Megalobatrachus*, and it is clearly recognizable, although rather weak, in *Necturus*.

In *Rana* I have termed deltoideus profundus an incompletely separable division of the deltoid which is comparable in character with the proscapulohumeralis brevis of *Necturus*. It is entirely deep to the superficial deltoid, arising from the acromion and border of the scapulo-acromial notch. It passes beneath (medial to) the latissimus tendon and inserts upon the posterior base of the pectoral ridge of the humerus. In some Salientia the border of the proscapulohumeralis presents the appearance of having fused with the adjoining coracoid division (Anthony and Vallois, 1914), and a similar condition may be encountered in Caudata (*Salamandra*). Neither Miner nor I attach any special significance to this fact. Superficial fusion of two muscles constantly occurs in phylogeny and seldom proves to have more than transitory significance.

Romer considers that this slip represents a teres minor, but a consideration of the insertional relations of the several muscles

of the shoulder indicates very clearly that the amphibian representative of that muscle is the *dorsalis scapulae*. What then does it represent? It was considered at first that it is the homologue of the *teres major*, as its insertion conforms to this thesis and the origin could easily migrate. A major difficulty in the way of this hypothesis, however, lies in the fact that it is separated from the *latissimus dorsi* by the axillary nerve, which is not the case with the *teres major* of mammals. It is possible, of course, that the nerve migrated through the muscle, but there is no evidence that this occurred. Hence it is wiser to consider that the *teres major* is derived from the *latissimus*, as Romer believes. Consequently it appears necessary to believe either that the *proscapulo-humeralis brevis* and *scapulohumeralis brevis* have both contributed to the *m. subscapularis*, or that one of them—most probably the former—has disappeared in mammals and is unrepresented.

This entire group of muscles, comprising all dorsal divisions of the intrinsic system of the girdle, is innervated by branches considered to comprise a homogeneous, axillary group of nerves, whether they occur as one main branch or some of them diverge from higher up, as they occasionally do. A point to be considered is that the *dorsalis scapulae* is at times supplied by two twigs. This may indicate a tendency for the muscle to divide into two parts, but may have no more significance than have the separate branches of the radial innervating the triceps.

Brachio-antibrachial matrix

In *Necturus* there are four divisions of the *anconeus*, or as I prefer to call the group, triceps, all with insertion upon the elbow, as follows:

M. humerotriceps lateralis (*anconaeus humeralis lateralis*) is the lateral division

adjoining the flexor group, with origin from the head of the humerus.

M. dorsi-triceps (*anconaeus scapularis*) is the division next posterior, with origin from the tendon of the *latissimus*; but there are a few muscle fibers extending from the glenoid margin to the *latissimus* tendon, which may represent a more proximal part of the division.

M. humerotriceps medialis (*anconaeus humeralis medialis*) is really more posterior than medial and is the deepest part of this complex. It arises from the posterior part of the proximal humerus.

M. coracotriceps (*anconaeus coracoideus*) is the most superficial of the medial muscles of the brachium, originating from the posterior base of the coracoid flexorward (anterior) to the brachial nerves and thus bridging them. It is thus an adductor as well as an extensor of the arm.

Miner prefers to divide the triceps of *Megalobatrachus* into medial or scapulo-humeral part, including what I term *dorsi-triceps* and *humerotriceps lateralis*, and a coracohumeral part, including *humerotriceps medialis* and *coracotriceps*.

In *Rana* there is no separable coracoid head. A *caput scapulare* originates mostly from the capsule of the joint but encroaches also upon the supraglenoid region of the girdle, passing superficial to the *nn. flexor brachii* and *pectoralis*. The humeral triceps here occurs in three parts, comprising *capita laterale*, *mediale*, and *profundum*, the latter being merely a separable part of the *caput mediale*.

Innervation of the triceps is by short twigs from *n. radialis*, in *Necturus* usually from the postaxial branch, with the exception of the *dorsi-triceps* of *Necturus*, which frequently receives a branch of the *n. thoracodorsalis*.

The brachium occupies a somewhat peculiar situation in regard to its musculature in that this segment may be oper-

ated effectively by girdle muscles inserting on the upper arm on the one hand, and antibrachial muscles arising from the distal humerus on the other. There is some indication that this may have been the basic plan, and it is difficult to decide, with both flexors and extensors, whether certain slips invaded the brachium from above or below. Not only is difficulty experienced in homologizing the triceps slips between *Necturus* and mammals, but even between the former and *Rana*. Largely because of conditions encountered in reptiles it is impossible to be certain whether the triceps heads are strictly homologous in different animals. At least, however, they are analogous.

Evidence indicates that it is a simple matter for a triceps division to change its origin from humerus to scapula via fascia or the capsule of the joint, or vice versa, but one cannot be sure that the same part of the complex has been involved or the same steps followed in diverse animals.

The conformation of the coracotriceps is particularly puzzling, arising as it does flexorward of the brachial nerves. Miner determined to his own satisfaction that in *Megalobatrachus* the upper part of the muscle is supplied by a twig of the n. coracobrachialis, indicating derivation from the latter group. If this actually be the case it would satisfactorily explain the puzzling features of the origin; but I sought such an innervation in twelve limbs of *Necturus*, under as high power of binocular magnification as was feasible, without success, and feel confident that in this animal innervation is by n. radialis alone. Furthermore stimulation of the flexor nerve components elicited no response by this division. In addition it is believed that origin of a triceps division from the coracoid is secondary, rather than fundamental. Either this head is partly derived from a group other than the triceps,

as indicated by Miner's work but not by my own, or it must have migrated by a fascial band to its present origin.

The scapulotriceps is phylogenetically a somewhat unstable slip, at times arising from the scapula (*Sphenodon*), scapular fascia (most lizards), capsule of the joint (some Caudata), partly from the humerus or from the latissimus tendon (*Necturus*). Personally I am unable to abandon the idea, at present, that the condition in *Necturus* is significant. In other words it seems likely that its association with the latissimus tendon is more than fortuitous, and hence that it may actually represent a displaced part of the latissimus dorsi.

There is considerable evidence that this "dorsitriceps" division has experienced a stimulus throughout its phylogeny for reaching the area of the girdle. In Salientia (*Rana*) it does so medial to both latissimus and dorsalis scapulae tendons, and clearly has reached the girdle by a fascial rather than by a bony pathway because it passes superficial to the n. pectoralis. In Reptiles (*Iguana*) it does the same by another pathway, lateral to the latissimus.

There are two humeral heads of the triceps so uniformly that it is considered that both together in Amphibia are represented in Reptilia and Mammalia, but whether the homologue of each can separately be recognized throughout the tetrapods is a different matter. They shift around considerably, occurring as lateral and medial, or superficial and deep, so that it would be a relatively simple matter for them to exchange places.

In the case of *Rana* I am inclined to think that the triceps head termed scapular may be considered as scapular and coracoid portions that have fused, which would naturally occur where there is no intervening obstacle, as in reptiles.

Ventral (flexor) division

Pectoral matrix (shoulder group)

M. pectoralis in *Necturus* has broad transverse origin from the ninth (?) myoseptum and sagittally from the midline. It inserts upon the anterior process of the proximal humerus. Its anterior border has practically an exactly transverse direction and it overlaps to a slight extent the major coracobrachial muscle.

In *Rana* I recognize three parts of this muscle, although four may be named. *Pars cutaneous* is a broad, exceedingly thin sheet from the same myoseptum as the *pars abdominis*, and inserts upon the skin beneath the episternum. It is of interest in being the only muscle occurring in vertebrates which simulates in essential details the *m. sternalis* occasionally occurring in man. *Pars abdominis* arises from a myoseptum well back upon the abdomen and from the border of the rectus sheath (therefore does not approach the midline), with insertion upon the distal pectoral process of the humerus. *Pars sternalis* is really double, with inferior origin from the xiphoid cartilage and superior origin from the sternum proper. Insertion is upon the anterior humerus medial to that of *pars abdominis*. The *pectoralis* is accordingly more extensive in *Rana* than it probably ever is in *Caudata*.

The *pectoralis* has the appearance of bearing the same relationship to the coracobrachial musculature that the *latissimus* does to the *dorsalis scapulae*, and functionally this is so. Both of the former may be considered merely as two divisions of the ventral musculature of the shoulder, but if more precise commitments be desired, then it must be supposed that both the muscle mass and nerves separated from the fused state at a time so early in phylogeny that the *n. coracoideus* had not yet been surrounded by the membra-

nous girdle; else the *n. pectoralis* would now pierce the coracoid foramen in amphibians. Insertion was probably basically upon the capsule of the joint.

It has been supposed by some that the *pectoralis* of amphibians represents the entire pectoral complex of mammals. This is incorrect. It must represent either the major or minor layer of mammals and it is easily seen that the latter is the case, for the pectoral nerve in *Amphibia* comes off from the posterior part of the plexus and the minor layer is similarly innervated in mammals. Thus the amphibian *pectoralis* represents *panniculus carnosus*, *pectoralis abdominis*, and *pectoralis minor* of mammals.

Anterior coracoid matrix (shoulder group)

The coracoid group of muscles, termed coracobrachial to distinguish them from the coracobrachial element, occurs in two divisions as follows:

M. coracobrachialis major (supracoracoideus part) in *Necturus* is the main muscle of the coracoid, arising from practically the entire ventral surface of the cartilage and inserting upon the anterior process of the proximal humerus.

M. coracobrachialis minor (supracoracoideus part) in *Necturus* is only secondarily separable from the major division, but in other forms it is often indistinguishable. It occurs as a small slip between the major and the *procoracobrachialis*, from the margin of the *procoracoideus*-coracoid notch, with insertion upon the anterior process of the proximal humerus.

In *Rana* there are three muscles in the coracoid group, as follows:

M. coracoradialis in *Rana* arises from the ventral episternal cartilage. It overlies much of the next division and underlies much of the *pectoralis sternalis*. It converges to a very strong tendon which passes deep down the brachium, beneath a

ligament medial to the pectoral crest of the humerus, and inserts upon the radius. This muscle constitutes the result of an effort on the part of *Rana* to manufacture a serviceable biceps of sorts.

M. coracobumeralis episternalis arises chiefly from the episternum largely beneath the coracoradial. It is a robust muscle which converges to insertion upon the medial epicondyle of the humerus.

M. coracobumeralis clavoacromialis (considered as two muscles by Ecker and Wiedersheim) in *Rana* is partly covered by the coracobumeralis episternalis and is two-headed. The smaller of these arises from the clavicle and the larger from the acromion. They fuse, and insertion is upon the pectoral ridge of the humerus.

Innervation of this group is by the coracoid nerve, piercing the coracoid foramen.

In *Megalobatrachus* Miner found that a deeper layer of the coracobumeralis was differentiated into a coracoradialis, apparently having thus developed by original connection with intermuscular fascia which eventually became tendinous. This explanation might well account for the condition in *Rana*, but it was not the situation in *Necturus*.

The history of the coracoid musculature in tetrapod ascent is one of the most interesting in myological morphology. Anchorage of the epicoracoid cartilages in the midline, which must have occurred before the recession of the coracoids was possible, allowed what may be considered as the major part of the coracobumeralis to take origin from the sternal region. This removed any need for broad coracoids and they accordingly receded to the point where they were of use only in furnishing narrow origin for brachial muscles. During this recession the coracoid nerve was liberated from its foramen and its restrictive influences. The portion of the coraco-

humeralis which settled to sternal origin now constitutes a part of the mammalian pectoralis. Such a derivation of any part of the pectoralis was denied by Miner, but his arguments are deemed untenable. The part concerned must be the major layer, for innervation of the minor shows clearly that the latter is derived from the original pectoral musculature. Hence the coracobumeral or pectoralis major layer has spread over the minor and increased in functional importance to the extent that its motor nuclei have embraced additional segments. Accordingly its nerve is now derived from posterior as well as anterior nerves of the plexus. The fact that these two muscle elements have for long functioned conjointly has doubtless been responsible for the close association of their nerves in mammals, and hence the more posterior of the nerve fibers to the pectorales major are given off in a common sheath with those of the minor, and both roots of the anterior thoracic nerve, with their connecting loop, are the result.

The more anterior or dorsal fibers of the coracobumeral appear to have had a different history. If the suprascapular nerve and musculature be not entirely unrepresented in modern Amphibia and Reptilia, and if they be ventral or flexor components, as I have somewhat reluctantly been compelled to believe, then they must have been derived from the part of the coracobumeral complex adjoining the dorsal procoracobumeral group, a thesis the essential features of which were advanced partly by Romer and by Miner. Certainly the suprascapular musculature could not have been derived from procoracobumeral (scapulohumeral) elements, as believed by Watson, and by Gregory and Camp, unless the former comprise axillary (dorsal) components

that have migrated to present position by a route medial to the scapula. Further discussion of this detail will be deferred for the contribution on the Reptilia.

Posterior coracoid matrix (shoulder group)

The morphology of this group will be discussed with the next.

M. coracobrachialis is so called to distinguish it from muscles of the coracohumeral group. In *Necturus* it lies deep to the posterior part of the coracohumeral major, arising from the base of the coracoid and inserting upon the medial side of the humeral head.

M. gleno-antibrachialis (coracobrachialis longus, biceps) in *Necturus* arises from the posterior tuberosity of the glenoid region of the girdle, and inserts not upon the humerus strictly speaking, as stated by Wilder, but upon the capsule of the shoulder joint. The fact that it bridges the n. flexor brachii is an indication that it migrated down the arm not by a bony pathway, but via the intermuscular septum.

Miner reports for *Megalobatrachus* an additional muscle for this group, termed coracobrachialis longus, which has the appearance of being a part of the shorter coracobrachial whose insertion has settled down upon the intermuscular fascia associated with the coracoradialis. It has thus migrated distally and could by this means become a perfectly proper biceps. His biceps brachii is comparable to my gleno-antibrachialis, but it had a tendinous inscription and may be composed of different elements (as brachialis plus coracobrachialis fibers).

In *Rana* there are three muscles in this division, perfectly distinct, but all with origin from the coracoid and separate insertions upon the proximal part of the

medial ridge of the humerus; hence none of this group acts as a biceps.

Innervation of this group of muscles is by the n. coracobrachialis.

Brachial-antibrachial group

The only muscle of this group to be considered in the present report comprises the following:

M. brachialis (humero-antibrachialis inferior) in *Necturus* arises from the anterior part of the proximal humerus and inserts between the antibrachial extensor and flexor groups upon the radius. There is no brachialis muscle as such in *Rana*.

Innervation is by a separate branch of n. flexor brachii.

As with the dorsal triceps division the interpretation of the brachial flexor musculature offers some difficulty. Fürbringer (1876) long ago pointed out that the biceps could not be derived from any part of the supracoracoid musculature, such as the coracoradialis of Salientia, because of the innervation of the latter. Romer expressed a similar belief, but then stated that the biceps may have arisen as a posterior part of the coracoradial, which would be an ambiguity. Romer also considered that the biceps (element?) is absent in modern Amphibia. Certainly no element of the brachial flexors of mammals has been derived from the complex supplied in Amphibia by the coracoid nerve, except that the two groups doubtless had common origin in the pretetrapod stage. Miner believed that the biceps is a development of the coracobrachialis group,—a thesis which is quite plausible insofar as concerns Amphibia. He also contended that the brachialis had similar derivation, but of this I am doubtful. There are certainly indications that the group may have been formed not only by distal extension of shoulder components (coracobrachialis),

but also by proximal migration of elbow elements, in which case the brachialis should be a product of the latter. The coracobrachialis of mammals is undoubtedly derived from the group of the same name in Amphibia.

The conformation of the coracoradialis in *Megalobatrachus* and *Rana* are presumably efforts to supply "biceps" control of the forearm, but the innervation of the former proves that it could have taken no part in biceps formation, except as its tendon

TABLE 1
Homology of Muscles of the Shoulder

<i>Dorsal Division</i>		
m. trapezius	trapezius	{ trapezius sternocleidomastoideus
absent	interscapularis	absent
m. levator scapulae } mm. serrati }	{ levator scapulae rhomboidei serrati }	{ levator scapulae rhomboidei serratus anterior
m. latissimus dorsi	latissimus dorsi	{ latissimus dorsi teres major (?) teres minor deltoideus post. part subscapularis
m. dorsalis scapulae	dorsalis scapulae	
m. procoracohumeralis longus	deltoideus superficialis	
m. scapulohumeralis brevis }	{ scapulohumeralis brevis deltoideus profundus }	
m. procoracohumeralis brevis }	c. scapulare tric.	
m. dorsitriceps }	{ c. laterale tric. c. mediale tric. c. profundum tric. }	
m. coracotriceps }		c. longum tric.
m. humerotriceps lateralis }		{ c. laterale tric. c. mediale tric.
m. humerotriceps medialis }		
<i>Ventral Division</i>		
mm. hypobranchiales	hypobranchiales	infrahyoid mm. { panniculus carnosus pectoralis abdominis pectoralis minor
m. pectoralis	pectoralis	{ ant. part subscapularis supraspinatus infraspinatus pectoralis major subclavius
m. coracohumeralis major }	{ coracoradialis coracohum. episternalis coracohum. clavo-acrom. }	
m. coracohumeralis minor }		
absent	absent	
m. coracobrachialis }	coracobrachiales (3)	coracobrachiales
m. gleno-antibrachialis }	c. super. flex. carpi rad. (??)	{ biceps brachii (?) brachialis
m. brachialis		

The Amphibia as well as the Reptilia have clearly had some difficulty in evolving a muscle with ordinary biceps function, and the persistency with which this has been attempted indicates the importance of such a muscle to their economy.

may have furnished a convenient avenue for migration of the insertion of coracobrachialis elements, as suggested by *Megalobatrachus*. The gleno-antibrachialis of *Necturus* is a biceps of sorts, but whether it can be homologized with either division

of this muscle in mammals is uncertain. It is not at all improbable that elements of the absent brachialis may in *Rana* be contained in the caput superior m. flexor carpi radialis (as of Fürbringer).

There is no differentiated muscle in modern Amphibia comparable to a m. subclavius, and the derivation of the latter muscle in mammals need not concern us here.

The antibrachial and podial musculature is also outside the field of the present investigation.

In summary table 1 presents concisely the probable homologies of the shoulder musculature of *Necturus*, as illustrating modern Caudata, *Rana* for Salientia, and of the typical mammalian condition. A single interrogation mark indicates a doubt, not of the group relationship of a muscle, but whether it is justifiable to carry commitments to such a fine point. A double interrogation signifies a question whether the muscle actually has representation in other forms. Where other items of uncertainty exist they are explained in the text.

DISCUSSION OF NERVE-MUSCLE ACTION

In the present investigation there was employed a stimulating apparatus consisting of a 6 volt transformer receiving an alternating current of 60 cycles, which was then passed through a small rheostat with voltmeter. The latter was not calibrated. Unipolar stimulation was found to be more satisfactory than bipolar. The stimulating electrode was provided with the usual platinum tip, and the indifferent electrode was introduced into the oral cavity. A series of more than a dozen *Necturus* was used, and as ether anesthesia raises the threshold of action to an undesirable degree the animals were pithed between occiput and atlas. Motor stimulation was then very

effective with current as low as one-tenth volt.

In spite of the fact that pithing was done with as much uniformity as possible there was extreme variability in the reflexes following this procedure. In some individuals these were of such strength as largely to simulate those of the intact animal, while in others the reflexes were sharply depressed. Individual variation in the responsiveness of muscles to the electrical stimulation of the nerves occurs, but not to a very marked extent.

The nerve impulses which react to direct electrical stimulation by effecting final muscular action are of two sorts, comprising the impulses caused by stimulating the efferent axons of the motor-neurons (motor twitch), and those caused by stimulation of the afferent elements of certain reflex arcs (reflex twitch). Just what sort of sensory fibers are concerned in the latter action is not yet known. They may be proprioceptive or some other sort of sensory pathways; hence they should not as yet be designated by specific name, but for convenience in reference they will herein be termed for the time being x-afferent fibers.

In lower as in many of the higher tetrapods limb action falls naturally into two categories, one concerned with the maintenance of elevation of the body and the other with its forward propulsion. The former involves nervous posture. In reptiles and higher vertebrates the postural center lies in the red nucleus of the brain, but Amphibia and Pisces have no red nucleus. Beyond question the latter classes possess nervous posture of sorts, although it is not manifested by decerebrate rigidity and but very little is known about it. The other useful function of the fore limb in Amphibia is that of locomotion proper, the movements for

which are of a very simple pattern, with coördination of numbers of muscles. Movements other than those concerned with locomotion are minimal. Separate contraction of individual muscles is likely either impossible or, if indulged in, may be considered as the initial step of a low stimulus that would, in stronger amount, bring into action all the muscles of a particular group.

Attention should be called to the fact that such an act as locomotion is brought about by a mosaic of interdependent reflexes, controlling most of the body muscles, and the simpler the neurological organization of the animal the more completely interdependent these are. The performance of a single action instigates other sequential actions, inhibits still others, and the sum of these reflexes results in a cycle of locomotion. It is only in higher forms that one encounters any number of reflexes that are not interdependent. Thus, as far as the locomotion of vertebrates is concerned, the primitive picture is not the single reflex, but the complex reflex pattern for locomotion, and only later is this, to some extent, broken up into its component parts. It must not be forgotten, however, that when vertebrate limbs were first developing the musculature was simple and that the reflexes concerned therewith were a very small detail of the total locomotor complex. Limb reflexes developed as the importance of the trunk in progression decreased.

Primitive muscle action must, then, be considered basically as group movement. In the earliest stages of the appendages a single group movement probably included only those muscles of the same phylogenetic derivation, as the extensors, or the flexors, but not parts of both groups at the same instant. At a later stage, however, there was undoubtedly some

realignment of action so that certain elements of separate muscle divisions, such as the extensors of the brachium and flexors of the antibrachium, could combine for some useful locomotor purpose. An additional step apparently involves the representation of a muscle in two different action groups.

Muscle action, and therefore nerve impulse, is not only rhythmic but basically sequential in the locomotor cycle. This may be illustrated by the sequence in muscular action as one stimulates successive brachial nerves of the dogfish, each step probably constituting a link in a reflex chain which the animal is possibly incapable of itself dividing. In higher forms the picture may be somewhat less clear cut, but the principle remains, and successive brachial nerves effect successive steps in the locomotor cycle of the limb concerned.

In *Necturus* the limb movements are simple and there are discernible but three distinct group actions in the pectoral limb. These can not be analyzed simply by stimulating the intact nerves, for the current would then be carried not only peripherally by the motor fibers, but also centrally by the sensory fibers of certain reflex arcs, motor axons of which may emerge from any or all of the brachial nerves. The afferent stimulation under this condition is not selective, as nature, stimuli must be, but violently inclusive and the action resulting is not coördinated but comprises a useless gyration. Accordingly one must interrupt the afferent pathway, most easily accomplished by cutting the nerves, after tying a fine thread about each one, and then stimulating the peripheral stumps. All affected pathways will then be motor.

At a fraction of a volt the electrode elicited from the peripheral stumps of the three brachial nerves three respective

actions which go to make up a complete locomotor cycle for that limb. Stimulation was begun at about one-tenth volt and was gradually raised to one volt, during which change different actions took place as respective thresholds were attained.

Stimulation of the peripheral stump of the first brachial nerve successively brought in (1) flexion of forearm, (2) adduction and (3) protraction of the brachium. Through the stump of the second brachial nerve was secured successively (1) flexion, and slight pronation, of the manus, (2) adduction of the digits in some cases, and (3) barely perceptible retraction of the upper arm. Stronger current accentuated the latter movement and extended the forearm. When the current was applied to the stump of the third brachial nerve the appearance superficially given was that this followed through and completed the action started by the second nerve. It differed in some particulars, however. Low current through this nerve elicited (1) flexion of wrist with extension, and in some individuals abduction, of the digits, then (2) extreme retraction of the rigidly straightened arm, and finally, at one volt, (3) sufficient flexion of the forearm to bring this beneath the body.

Stated differently, stimulation of the peripheral stumps shows that the first brachial nerve bends the forearm and brings it forward partly beneath the body, so that the limb is in an advantageous position to pull and then push the body onward as the member is straightened and retracted by stimuli through the second and third nerves. The final action through the latter is slight flexion of the forearm, which is in effect the initial step toward a repetition of the entire cycle.

It must be mentioned that there is some slight individual variation in the above

reactions. For instance abduction and adduction of the digits is not marked in some individuals. At times also retraction of the arm is more pronounced through the second than the third nerve. Variation of the latter sort may well be correlated with differences known to occur in the distribution of the electrically stimuable afferent fibers. Attention should also be called to the fact that the latter can not react to stimuli after the nerves are cut, so stimulation of the peripheral stumps of a cut plexus cannot present a precisely accurate picture of natural limb movement. Neither does electrical stimulation of the peripheral stump of a cut nerve take into account such inhibition of action as may occur in normal reflexes.

Coördination of limb movement implies not only that the afferent side of the reflexes concerned is in good working order, but that the pathway between the motor nuclei of the brachial segment of the cord and the limb musculature is intact. If the limb bud of a larval amphibian be transplanted several segments anterior or posterior to the normal situation the brachial nerves will make a strong effort to reach it, and will do so providing the distance is not great, as is known from the work of Detwiler and others. Movement of the limb will occur if the motor fibers of any nerve reach the limb, but coördinated movement of a useful sort will take place only providing the axons from at least one of the brachial nerves can reach the appendage (Detwiler, 1929). Such coördination, though doubtless considerably impaired, is present even if only a small branch from the last brachial nerve reaches the limb, and hence it is evident that such a branch will carry a muscle load much in excess of normal. I have verified the latter statement by extirpating large segments of one or

another of the brachial roots of *Trisurus*. After a matter of some two weeks the initial impairment of function had been partly but not completely remedied, although the hiatus in the cut nerve had not been bridged. It appears likely that this was accomplished by the establishment of new reflex connections within the cord—not by a change in the motor axons or the periphery of the nerve.

In pithed *Necturus*, impact upon the sole of an anterior limb resulted in feeble movement of it and the contralateral member. Stretching was without contralateral effect.

In *Necturus* it was found that electrically stimuable afferent fibers are carried by the third and fifth spinal nerves, but not usually by the much larger fourth. This was determined as follows: In a pithed animal the fifth nerve was cut and the central stump was stimulated. Definite action resulted when the current reached a height of one and a quarter or one and a half volts, and in addition there was contraction of the ipsilateral trunk musculature of the region. The third nerve was then cut and stimulation of its central stump had the same results. In both cases the limb movement was vague and uncorrelated, probably because of the nonselectivity of the impulse. Upon the opposite side, or upon a fresh animal, the fourth nerve was then cut and its central root stimulated. In one case slight movement resulted, but in the others there

was not a tremor, even in consequence of a current of five volts.

In order to determine whether the third nerve carries stimuable afferent fibers synapsing with motor elements emerging by way of the fifth nerve, and vice versa, the third and fourth spinal nerves of *Necturus* were sectioned and $1\frac{1}{2}$ volts applied to the central stump of the third. No arm movement resulted, although there was some contraction of the neighboring trunk musculature. On the opposite side of the same individual the fourth and fifth spinal nerves were similarly treated. Stimulation of the central stump of the fourth elicited fewer movements of the body and feeble adduction (flexion) of the brachium.

The above results indicate that the third and fifth spinal nerves of *Necturus* carry electrically stimuable, afferent fibers which synapse with motor neurons whose axons attain the limb by way of the fourth nerve, and with other neurons of the trunk muscles. One individual indicated that no x-afferent fibers of the third nerve synapse with efferents of the fifth, but that some x-afferents of the fifth do synapse with efferents of the third. Some individual variation in this pattern may be expected. The x-afferent fibers consistently have a higher threshold than motor fibers. It is thus seen that the stimulation of a single nerve of an intact plexus may initiate reflex action in any other nerve of the plexus.

LIST OF LITERATURE

(Not including a number of titles listed in Parts I and II)

- ANTHONY, R. 1913. The morphology of the shoulder girdle. 17th Internat. Cong. Med., Sect. 1, Anat. & Emb., pp. 239-272.
- and VALLON, H. 1914. Sur la signification des éléments ventraux de la ceinture scapulaire chez les batraciens. *Bibl. Anat.*, vol. 24, pp. 218-276.
- BAUR, G. 1896. The Stegocephali. A phylogenetic study. *Anat. Anz.*, vol. 11, pp. 657-673.
- BRAUS, H. 1906. Die Entwicklung der Form der Extremitäten und des Extremitätenskeletts. In Hertwig, O. Handb. der Vergleichenden und Experimentellen Entwicklungslehre der Wirbeltiere, vol. 3, pt. 3, pp. 167-336.
- BROOM, R. 1913. On the origin of the cheiropterygium. *Bull. Amer. Mus. Nat. Hist.*, vol. 32, pp. 459-464.

- BRYANT, W. L. 1919. On the structure of *Eurythoneura*. *Bull. Buffalo Soc. Nat. Sci.*, vol. 13, no. 1, pp. 1-58.
- DEAN, B. 1888. On the shoulder girdle and extremities of *Eryops*. *Trans. Amer. Phil. Soc.*, N.S., vol. 16, pt. 2, pp. 362-367.
- DETWILER, S. R. 1922. Experiments on the transplantation of limbs in *Amblystoma*—Further observations on peripheral nerve connections. *Journ. Exper. Zool.*, vol. 35, pp. 115-161.
- . 1929. An experimental study of the mechanism of coordinated movements in heterotopic limbs. *Journ. Comp. Neurol.*, vol. 47, pp. 427-447.
- ECKER, A., and WIEDERSHEIM, R. 1896. Anatomie des Frosches. *Braunschweig*, vols. 1 and 2.
- EMERY, C. 1894. Studi sulla morfologia dei membri degli Anfibi e sulla filogenia del chiropterygio. *Ricerche Lab. Anat. Norm. Univ. Roma*, vol. 4, pp. 5-35.
- ENGLER, E. 1929. Untersuchungen zur Anatomie und Entwicklungsgeschichte des Brustschulterapparates der Urodelen. *Univ. Zurich, Dis.*, pp. 143-229.
- FIELD, H. H. 1894. Die Vornierenkapsel, ventrale Muskulatur und Extremitätenlagen bei den Amphibien. *Anat. Anz.*, vol. 9, pp. 713-724.
- FUCHS, H. 1922. Beiträge zur Entwicklungsgeschichte und vergleichenden Anatomie des Brustschulterapparates der Wirbeltiere: über den Schultergürtel der Amphibia anura, nach Untersuchungen am braunen Grasfrosch (*Rana fusca*): I. Suprascapulare und Cleithrum, Procoracoid und Thoracale ("Clavicula"). *Zeitsch. Morph. Anthropol.*, vol. 22, pp. 283-328.
- FÜHRBINGER, M. 1873. Zur vergleichenden Anatomie der Schultermuskeln. Theil I. *Jena. Zeitsch. Med.*, vol. 7, pp. 237-320.
- . 1874. Theil II. *Ibid.*, vol. 8, pp. 175-280.
- . 1876. Theil III. *Morph. Jahrb.*, vol. 1, pp. 636-816.
- . 1879. Zur Lehre von den Umbildungen der Nervenplexus. *Morph. Jahrb.*, vol. 5, pp. 324-394.
- GREGORY, W. K. 1915. Present status of the problem of the origin of the Tetrapoda with special reference to the skull and paired limbs. *Ann. N. Y. Acad. Sci.*, vol. 26, pp. 317-383.
- , MINER, R. W., and NOBLE, G. K. 1923. The carpus of *Eryops* and the structure of the primitive chiropterygium. *Bull. Amer. Mus. Nat. Hist.*, vol. 48, pp. 279-288.
- HARRISON, R. G. 1915. Experiments on the development of the limbs in Amphibia. *Proc. Acad. Nat. Sci.*, vol. 1, pp. 539-544.
- HARRISON, R. G. 1918. Experiments on the development of the fore limb of *Amblystoma*, a self-differentiating equipotential system. *Jour. Exper. Zool.*, vol. 25, pp. 413-461.
- HOFFMAN, C. K. 1873-1878. Amphibien. Bronn, *Klass. Ord. Tierreichs, Leipzig*.
- HOWELL, A. B. 1933a. Morphogenesis of the shoulder architecture. Pt. I. General considerations. *QUART. REV. BIOL.*, vol. 8, pp. 247-259.
- . 1933b. Morphogenesis of the shoulder architecture. Pt. II. Pisces. *QUART. REV. BIOL.*, vol. 8, pp. 434-456.
- . 1935. The primitive carpus. *Jour. Morph.*, vol. 57, pp. 105-112.
- HUMPHRY, G. M. 1871. The muscles and nerves of *Cryptobranchus japonicus*. *Journ. Anat. & Physiol.*, vol. 6, pp. 1-61.
- . 1872. Observations in Myology, Including the Myology of *Cryptobranch*, *Lepidosiren*, Dogfish, *Ceratodus* and *Pseudopus pallasii*, with the Nerves of *Cryptobranch* and *Lepidosiren* and the Disposition of Muscles in Vertebrate Animals. *London*, 192 pp.
- HUNTINGTON, G. S. 1918. Modern problems of evolution, variation and inheritance in the anatomical part of the medical curriculum. *Anat. Rec.*, vol. 14, pp. 359-387.
- JAKKELO, O. 1909. Ueber die Beurteilung der paarigen Extremitäten. *Sitz. Ber. Kön. Preuss. Akad. Wiss.*, pp. 707-724.
- KERR, A. T. 1918. The brachial plexus of nerves in man. The variations in its formation and branches. *Amer. Jour. Anat.*, vol. 23, pp. 285-395.
- KERR, J. G. 1900. Note on hypotheses as to the origin of the paired limbs of vertebrates. *Proc. Cambridge Philos. Soc.*, vol. 10, pp. 227-235.
- KLAATICH, H. 1896. Die Brustflosse der Crossopterygier. Ein Beitrag zur Anwendung der Archipterygiumtheorie auf die Gliedmassen der Landwirbelthiere. *Festsch. C. Gegenbaur*, vol. 1, pp. 259-392.
- MINER, R. W. 1925. The pectoral limb of *Eryops* and other primitive tetrapods. *Bull. Amer. Mus. Nat. Hist.*, vol. 51, pp. 145-312.
- NOBLE, G. K. 1931. The Biology of the Amphibia. *N. Y.*, 577 pp.
- OSAWA, G. 1902. Beiträge zur Anatomie des japanischen Riesensalamanders. *Mitteil. Med. Facultät K.-Jap. Univ. Tokio*, vol. 5, pp. 221-427.
- OSBURN, R. C. 1907. Observations on the origin of the paired limbs of vertebrates. *Amer. Jour. Anat.*, vol. 7, pp. 171-194.
- PARKER, W. K. 1868. A Monograph on the Struc-

- ture and Development of the Shoulder-girdle and Sternum in the Vertebrata. *Roy. Soc. London*, 237 pp.
- PERRIN, A. 1899. Contributions a l'étude de la myologie et de l'ostéologie comparée: membre antérieur chez un certain nombre de Batraciens et de Sauriens. *Bull. Sci. France et Belgique*, vol. 32, pp. 220-535.
- RABL, C. 1901. Gedanken und Studien über den Ursprung der Extremitäten. *Zeitsch. wiss. Zool.*, vol. 70, pp. 474-558.
- RIBBING, L. 1907. Die distale Armmuskulatur der Amphibien, Reptilien und Säugetiere. *Zool. Jahrb.*, vol. 23, pp. 587-680.
- ROGERS, W. M. 1933. The influence of the developing fore limb on nerves arising from heterotopic spinal cord transplants in *Amblystoma*. *Anat. Rec.*, vol. 58, pp. 71-92.
- ROMER, A. S. 1922. The locomotor apparatus of certain primitive and mammal-like reptiles. *Bull. Amer. Mus. Nat. Hist.*, vol. 46, pp. 517-606.
- . 1924. Pectoral limb musculature and shoulder-girdle structure in fish and tetrapods. *Anat. Rec.*, vol. 27, pp. 119-143.
- and BYRNE, F. 1931. The pcs of *Diadectes*: notes on the primitive tetrapod limb. *Palaeobiologica*, vol. 4, pp. 25-48.
- . 1933. Vertebrate Paleontology. *Univ. Chicago Press*, 491 pp.
- RYLKOFF, H. 1924. Die Entwicklung der Schultermuskeln bei urodelen Amphibien. *Zeitsch. Wiss. Zool.*, vol. 122, pp. 116-171.
- SABATIER, A. 1880. Comparaison des Ceintures et des Membres Antérieurs et Postérieurs dans la Série des Vertébrés. *Montpellier*, 455 pp.
- SCHMALHAUSEN, I. 1917. On the extremities of *Ranidens sibiricus*. *Rev. Zool. Russe*, vol. 2, pp. 129-135.
- . 1917. On the dermal bones of the shoulder-girdle of the Amphibia. *Rev. Zool. Russe*, vol. 2, pp. 102-110.
- SIEGLBAUER, F. 1904. Zur Anatomie der Urodelenextremität. *Arch. Anat. Physiol., Abt. Anat.*, pp. 385-404.
- SNYDER, C. N. 1904. Locomotion in *Batrachoseps* with severed nerve-cord. *Biol. Bull.*, vol. 7, pp. 280-288.
- STEINER, H. 1921. Hand und Fuss der Amphibien, ein Beitrag zur Extremitätenfrage. *Anat. Anz.*, vol. 53, pp. 513-542.
- VERSLUYS, J. 1909. Die Salamander und die ursprünglichsten vierbeinigen Landwirbeltiere. *Abdr. Naturwiss. Wochens.*, vol. 8, pp. 1-28.
- WATSON, D. M. S. 1913. On the primitive tetrapod limb. *Anat. Anz.*, vol. 44, pp. 24-27.
- . 1917. The structure, evolution and origin of the Amphibia. The 'orders' Rachitomi and Stereospondyli. *Phil. Trans. Roy. Soc.*, vol. 209, B, pp. 1-73.
- . 1918. The evolution of the tetrapod shoulder-girdle and fore-limb. *Jour. Anat.*, vol. 52, pp. 1-95.
- . 1926. The evolution and origin of the Amphibia. *Philos. Trans. Roy. Soc. London*, vol. 214, pp. 189-257.
- WILDER, H. H. 1912. The appendicular muscles of *Necturus maculosus*. *Zool. Jahrb., Suppl.* 15, pt. 2, pp. 383-424.





DELAYED IMPLANTATION AND DISCONTINUOUS DEVELOPMENT IN THE MAMMALS

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INTRODUCTION

IT HAS long been a matter of general knowledge that the rate of development of the cold-blooded vertebrates is highly variable; the rate of growth of a frog embryo, for example, being almost as exact a function of the temperature as is the speed of a chemical reaction. Even the birds have retained to some degree this power of slowing or temporarily suspending growth for the several hours or days intervening between laying and incubation. It seems, however, to be generally believed that the mammalian ovum, with its intrauterine development at practically constant temperature, has gotten completely away from the archaic habit of hesitating in its growth. At least the idea that a mammalian embryo may suddenly come to a dead stop in its development and remain quiescent for weeks or months before resuming its growth would probably come as a shock to many biologists who are not familiar with embryological literature. Yet we know at present of a dozen mammals whose period of gestation is regularly from two to six months longer than actual embryonic development, and in six of these species we have definite embryological proof that this lengthening of pregnancy is due to a quiescent period interpolated in the development. In addition to this group of species in which the quiescent period is a normal feature of development, there are several species of rodents in which development

has been experimentally slowed down or temporarily stopped by various means; but at present it is uncertain as to whether this ever occurs except under the artificial conditions of the laboratory.

In spite of its unexpectedly frequent occurrence, the fact that mammalian development may be even more discontinuous than that of bird, frog, or fish has scarcely found its way into the text or reference books; certainly none of them gives any idea of the frequency with which this phenomenon is found. This cannot be blamed on any recency of the work, for seven of the cases have been known for more than forty years. It is not only the writers of texts who have overlooked this field; some of the investigators who have worked in it have been almost as negligent in ignoring the work done in other countries or on other forms. In the following pages I wish to summarize our present knowledge of the subject in the hope of making the facts more generally known and of stimulating additional work in the field.

STATEMENT OF PROBLEM

Our present interest is not in all types of lengthened gestation but only in those where the lengthening is the result of a slowing down or complete cessation of growth between the times of ovulation and of parturition. This may be made clearer by a brief review of the development of a typical mammal. Copulation and ovulation ordinarily occur within a

few hours of each other, the physiological changes which accompany ovulation determining the acceptance of breeding by the female. Fertilization thus takes place shortly after ovulation, usually in the upper part of the Fallopian tube. Cleavage goes on as the ova, or ovum, pass down the tube, and in most species these have already become blastocysts by the time they reach the uterus. As soon as the blastocysts come in contact with the uterine mucosa they attach themselves (implant) and begin the formation of the placenta. This implantation is directly controlled by a hormone secreted by the corpora lutea formed by the discharged Graafian follicles. Implantation and the formation of the placenta in no wise interrupt the growth of the ovum, the cells not concerned with implantation going ahead to form the embryo proper which continues growing in size and maturing in form throughout its intrauterine life. From ovulation to parturition the development of the embryo is a continuous, never ceasing process, one stage merging into another with the smoothness and continuity of a well-made movie film.

In sharp contrast to the foregoing is the type of development which we have called "discontinuous." In this we find the preliminary stages the same,—ovulation, fertilization, cleavage, the formation of a blastocyst. Now, however, development suddenly stops. The cells cease dividing, the blastocyst does not attach to the uterine mucosa. To continue our simile, the "movie" has suddenly become a "still," leaving a single exposure of the film projected on the screen. This stage may last for months, neither blastocyst nor uterus undergoing any discernible change. Sooner or later, however, activity resumes with the same abruptness with which it left off, the blastocyst implants, and its further history is exactly as though it had

never paused in its progress from single cell to independent individual.

Discontinuous development must not be confused, as has been done by some writers, with a simple lengthening of gestation, for the latter may be due to causes other than the presence of a quiescent period. In a general way there is a rough correlation between the size of the animal and the length of gestation, and these two factors in turn largely determine the size of the young at birth. We sometimes find an animal with a gestation period unexpectedly long, as in the guinea pig where gestation lasts 63 days instead of only 20 to 40 days as in most rodents. Here, however, we find the young very large in proportion to the size of the mother, for in the guinea pig the embryo undergoes active growth during all the 63 days of pregnancy, so that the long gestation is not the result of any delay in development. Similarly we find that cases of exceptional lengthening of gestation in the human are accompanied by a proportional increase in the size of the fetus, so we may feel sure that here, too, there has been no interruption of development. It is only when an unexpectedly long gestation produces a disproportionately small fetus that we may suspect the occurrence of a delay in the growth of the embryo.

There is another type of reproductive cycle which may be mentioned here, as it offers a possibility of confusion with the type which we are to discuss. In most bats of the families Vespertilionidae and Rhinolophidae copulation takes place in the fall, the sperm are retained in the uterus through the winter, and ovulation occurs the following spring. There is thus an interval of some eight months between copulation and parturition, but this is due not to any lengthening of development but to a delay in ovulation, the actual gestation lasting only a few weeks.

These bats, then, are not included in the group of species which we are to discuss.

REVIEW OF THE LITERATURE

I shall not try to review the literature in detail, but will merely mention the more important contributions in their chronological order. It should be noted that most of the work has been based solely upon observations of the living animal, few of the investigators having seen actual embryological material. Besides the papers cited in the bibliography, there are endless references in zoological literature to the very long gestation of some of these animals. Most of these are given at second or third hand, and as they do not appreciate or discuss the possible causes of the lengthening of pregnancy, they are of little importance to our survey of the problem.

The earliest reference to lengthened gestation seems to be an article by Ziegler in 1843 on the biology of the roe-deer, *Capreolus*. Ziegler made no embryological examination. This was done in 1854 by Bischoff, who described a quiescent stage in the development of the ovum and fixed the approximate duration of this stage. In 1873 Herbst discussed the breeding time and gestation period for the European badger, *Meles*, as in the case of Ziegler without having seen any of the early stages. These were first described by Fries in 1880. Fries fixed the approximate time of implantation and naturally drew comparisons between the badger and the roe-deer.

In 1891 there appeared a remarkable paper by Lataste, in which he described, for five species of rodents, the lengthening of gestation found in lactating, pregnant animals. While he did not actually see the unimplanted blastocysts, he noted that the animals had ovulated but that the uteri showed no signs of implantation un-

til several days after this would normally have occurred. He concluded (correctly, as we now know) that the prolongation of gestation was the result of a slowing down or cessation of development in the cleavage stages or blastocysts, and he even carried out some experiments to analyze the causes of the interruption.

From 1899 to 1902 a series of articles by Keibel brought our knowledge of the roe-deer to practical completion. Bischoff's earlier observations were confirmed, in the main, and were supplemented by the study of several score of ova from the quiescent period. Retzius, in 1900 (see also his discussion of Keibel's 1899 paper) independently studied the roe-deer and made a careful comparison with the reindeer, in which no delayed development is found. In the same year there appeared a preliminary paper by Fischer on the badger, which, however, added little to Fries' earlier findings.

The next half-dozen papers on the subject came from American zoologists. In 1910 and 1913 Daniel and King respectively confirmed for albino mouse and rat the earlier findings of Lataste. Neither author actually saw the quiescent ova. Also in 1913 Patterson described the early development of the polyembryonic armadillo, *Dasyurus (Tatusia) novemcinctus*, and announced the discovery of a quiescent period immediately preceding implantation, the period being at least three weeks in duration. The free vesicles were actually recovered and described, so that the armadillo made the third species for which actual embryological evidence of the quiescent stage was available. A fourth was added in 1916 when Kirkham recovered free blastocysts from mice in which implantation was delayed by suckling. Kirkham's 1918 paper merely amplified his previous one, but in 1926 Teel advanced the problem a step by experi-

mentally inducing the delay with injections of hypophyseal extracts.

In the following year, Ashbrook and Hanson reported some breeding experiments which they had been carrying on for several years with the American marten, and which showed a very long period of gestation in this species. In that same year there appeared two articles by Prell, dealing with the long pregnancy (verlängerte Tragezeit) found in the martens. Prell's data were largely drawn from field observations, while Ashbrook and Hanson had carefully checked records of caged animals to go by. In the following three years there appeared a large number of German papers, by various authors, dealing with the observed, suspected, or possible lengthening of gestation in martens, fisher, wolverine, badgers, and bears. In none of these articles, however, were there set forth any observations of actual ova or embryos. All were based upon observations of the times of breeding and of parturition, together with a comparison with the established cases of the roe-deer and the badger. None of the investigators seems to have known of the work on the mouse and the armadillo.

In the meantime, however, other more strictly embryological investigations were in progress. Hamlett, in 1929, in a report to the Society of Zoologists, established the length of the free vesicle stage in the armadillo as being fourteen weeks; and showed that the American badger had a similar quiescent period, and probably the black bear also. In 1931 Fischer described in detail the reproductive cycle of the European badger. His material covered the whole quiescent period and was thus far more complete than that of Fries. In the following year, 1932, two articles by Hamlett completed the story of the armadillo and described material from the badger through two and one half months

of the quiescent period and the actual embryogeny. Since 1930 there has also been a revival of interest in the rat and mouse, papers dealing with delayed implantation in these forms having been published by Mirskaia and Crew, Enzmann, Saphir and Pincus, Hain, and Enzmann during this period. None of these papers adds materially to the earlier findings of Lataste and Kirkham.

PRESENT KNOWLEDGE

In summarizing our present knowledge of this subject, I shall discuss one species in detail and use it as a basis of comparison for the other forms. I am choosing for this the nine-banded armadillo, partly because I am personally familiar with it, but more particularly because our knowledge of the reproductive cycle is more complete for it than for any of the other species.

Order Xenarthra

Dasypus (Tatusia) novemcinctus

Nine-banded armadillo, tatú gallinba

The papers of Patterson, Newman and Patterson, and Hamlett describe the embryology from the four-cell stage to birth. Our knowledge of the reproductive cycle (papers of Patterson and of Hamlett) is based upon the examination of over two thousand females, killed at intervals throughout the year. This species and the following one are polyembryonic, the single ovum of *novemcinctus* giving origin regularly to four embryos, that of *D. hybridus* to as many as twelve.

The nine-banded armadillo breeds, in Texas, during July. In most years it is exceptional to find a female that has ovulated during the first week of July, and most of the breeding females will have done so by the end of the month. Cleavage stages were actually recovered from

the tubes on July 9 and 16, 1928. July 15 may be taken as an average date for the time of ovulation. In a few days (5-7?) the ovum develops into an inner-cell-mass blastocyst and enters the uterus. Development ceases at this point, apparently coming to an absolute stop. The cessation of activity would seem to be inherent in the ovum, at least in this form, for vesicles washed from the lower end of the tubes seem to have attained full size and to have stopped cleavage. This would imply that the failure of implantation is not the only factor responsible for the quiescent period. The vesicle remains free in the uterine lumen until the early part of November, when the trophoblast cells become active, implantation takes place, and the differentiation of the inner cell mass begins.

During all this time the corpus luteum has been the most conspicuous feature of the ovary, one might almost say of the whole reproductive tract, for the uterus is not strikingly changed from the non-pregnant organ. Despite its large size, the corpus seems to be inactive; and this conclusion is supported both by histological study and by the completely negative results attending its removal during this period. Implantation is attended (probably preceded) by the appearance in the luteal cells of secretory droplets which give the peripheral cytoplasm a vacuolated structure. The general appearance is strikingly similar to what Corner has described for the corpora lutea of the sow. The removal of the corpus luteum after implantation is followed promptly by the abortion or resorption of the ovum. Implantation would thus seem to depend upon the secretory activity of the corpus luteum. We have at present no evidence as to the mechanism controlling the corpus, but it is doubtless correlated in some way with the pituitary.

The further development of the ovum, except for the budding of the amniotic vesicle to form the four embryonic shields, shows nothing of an unusual nature; nor can the polyembryonic feature be connected with the delay in development for it is found only in the armadillos and not in the other species which exhibit a quiescent period. The birth of the quadruplets takes place early in March (specimens from São Paulo and Matto Grosso, Brazil, show free vesicles, but I do not have enough material to fix the dates of the cycle in this region). We find accordingly in this form a total length of gestation of nearly eight months; made up of a "free-vesicle" stage of three and a half or four months and an actual development of about four months.

Dasypus hybridus

The mulita armadillo, tatú merim

Our evidence for this armadillo is indirect. Fernandez, who described the development of the embryos, failed to obtain stages prior to implantation; but he noted the presence of a corpus luteum two months earlier than he found the youngest embryos. By a comparison with *D. novemcinctus*, I believe we may safely assume that the mulita has a quiescent stage in its development. Implantation in Argentina takes place about June 1, the birth of the young in October. Having no data as to the time of breeding, we cannot fix definitely the duration of the free vesicle stage, except that it must be at least two months long. The active embryogeny lasts about four months, as in the Texas species.

Order Artiodactyla

Capreolus capreolus

European roe-deer

This is the only member of its order known to show a delay in implantation.

Our information concerning it is to be found in the papers of Ziegler, Bischoff, Retzius, and Keibel, the latter giving by far the most complete account. *Capreolus* breeds in August and implantation takes place in December. It is notable that in this species there is not a complete pause in development. A monodermic blastocyst is formed within a few days after fertilization, then during the ensuing four months the entoderm, primary amniotic

logical proof is available for the badgers alone.

Meles meles

European badger

Actual embryological data are given by Fries and by Fischer. *Meles* breeds late in July or early in August. Free vesicles are to be found in the uterus from that time until the latter part of January. Fischer describes them as slowly expand-

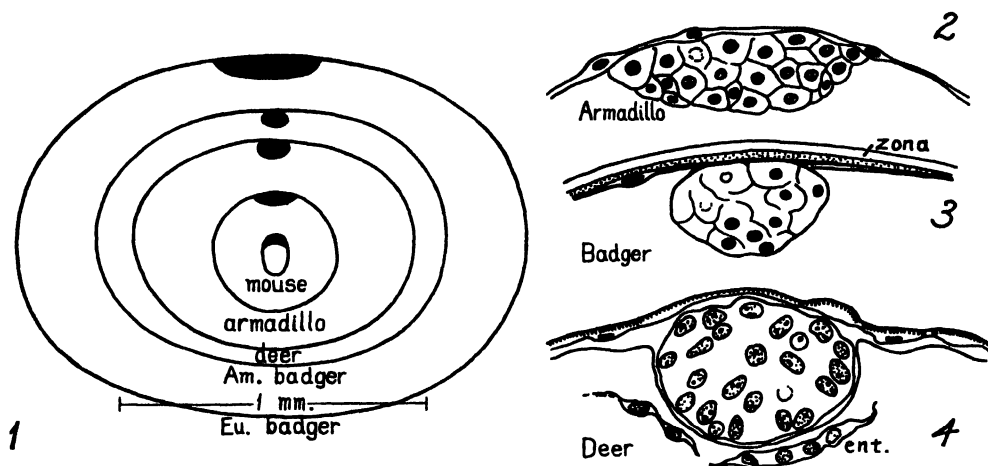


FIG. 1. OUTLINES OF BLASTOCYSTS FROM ABOUT THE MIDDLE OF THE QUIESCENT PERIOD, TO SHOW THE RELATIVE SIZES OF VESICLES AND INNER CELL MASSES IN THE VARIOUS SPECIES

The data used in constructing these are the original measurements and illustrations given in publications of Fischer, Hamlett, Keibel, Patterson, and Enzmann.

FIG. 2. DETAIL OF INNER CELL MASS OF ARMADILLO BLASTOCYST IN QUIESCENT STAGE After Patterson. No zona present at this time. $\times 320$.

FIG. 3. INNER CELL MASS OF BADGER (*TAXIDEA*) VESICLE DURING QUIESCENT PERIOD The zona persists until just before implantation. From photomicrograph. $\times 320$.

FIG. 4. INNER CELL MASS OF ROE-DEER FROM MIDDLE OF FREE VESICLE STAGE Note the presence of entoderm cells at this early period, characteristic of this species. After Keibel. $\times 320$.

cavity, and embryonic shield are slowly formed. This is unlike anything known from the other forms with delayed implantation. The fawns are born in May. The free vesicle stage lasts four months, the post-implantation development five months.

Order Carnivora

Two families and six genera apparently show the phenomenon. Definite embry-

ing, but does not describe any advance in their differentiation. Implantation takes place in January and the young are born in March. The free vesicle stage is six months long, active development two months or less.

Taxidea americana

American badger

This species has been studied by Hamlett. The earliest ova obtained were free

uterine blastocysts, found early in December. The species apparently breeds in August or September, judging from certain naturalists' observations, and presumably the ova would enter upon the quiescent stage a few days later. Up to this time no material has been available for the fall months. Free vesicles are found in the uterus through December, January, and the early part of February. Implantation occurs about February 15 and the young are born about the first of April. There does not seem to be any enlargement of the free vesicle such as Fischer describes in *Meles*. The free vesicle stage lasts at least two and a half months, probably six; duration of embryogenesis is about six weeks.

<i>Martes americana</i>	Pine marten
<i>Martes martes</i>	Beech marten
<i>Martes foina</i>	Stone marten
<i>Martes zibellina</i>	Siberian sable

Because of their value as fur-bearers, these animals have been the objects of numerous attempts at breeding them in captivity. The results in the past have been exceedingly conflicting; it is only recently that any carefully checked records have been available. The earliest and best of these are those of Ashbrook and Hanson on the pine marten. The animals pair during July and August, the young are born in April or May. In one case Ashbrook and Hanson isolated a female on September 4, the animal gave birth to a litter the following April. All recent observations on the Old-world species agree with those on the pine marten, except that pairing may be even earlier, in May or June.

Up to date we have not been fortunate enough to secure unimplanted vesicles from the quiescent period. We do have definite evidence, however, that we are dealing here with a true case of discon-

tinuous development and not merely with another case of delayed ovulation such as is found in the bats. In the course of some work for the Division of Fur Resources of the Biological Survey I have had occasion this year (1935) to section the reproductive organs of two female martens from the fur-animal experiment station at Saratoga Springs. One of these animals died on August 1, the other on November 20. The ovaries of each animal show typical corpora lutea, conclusive proof that ovulation had occurred. Unfortunately, no blastocysts were found in either animal, possibly because fertilization had failed, possibly (in one case) to poor preservation. It must be remembered that the percentage of sterile matings is often high in these captive animals. Prell, also, states in one of his papers (1930b) that he has seen corpora lutea in the ovaries of a marten (stone marten?) long before the time when embryos are discernible in the uterus. There seems no longer any doubt but that the martens exhibit discontinuous development, although it is still desirable to complete the proof by actually recovering unimplanted blastocysts during the autumn months.

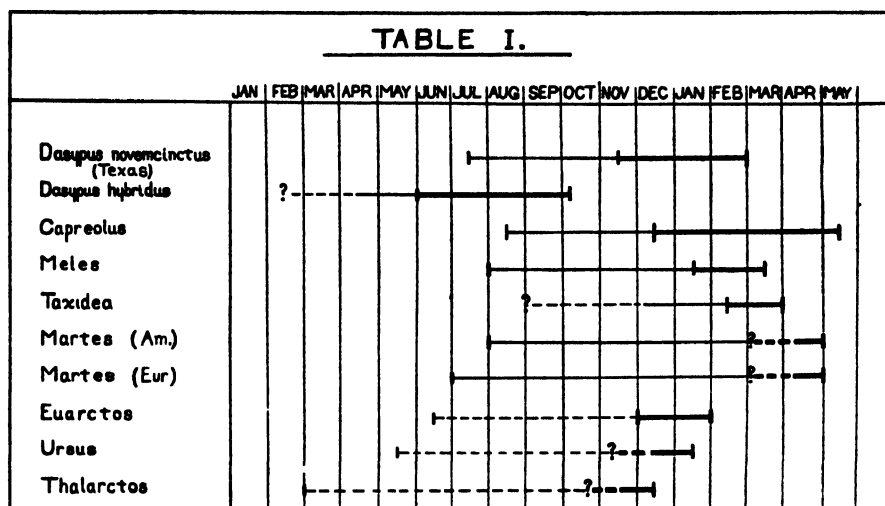
Euarctos americanus

Black-bear

This seems to come the nearest of the bears to having definite proof for the quiescent period, although even here there is the possibility of another explanation for the observed facts. In the first place there is ample evidence to show that the black-bear pairs in spring or early summer, May to early July (Seton, Heller, Baker). We know also that macroscopically visible embryos are not to be found until winter. The writer has in his collection a 2-mm. embryo which was obtained through the cooperation of the Pennsylvania Board of Game Commissioners. This embryo was

taken from a bear killed December 2. Implantation therefore probably took place during the last week in November. The cubs are born during the latter part of January or the first days in February. They are absurdly small for the size of the mother, being about twelve ounces in weight or slightly larger than a new-born kitten, and plainly can have been developing for only a few weeks instead of for the half year since the mother bred.

show the latter phenomenon, while delayed implantation is of more frequent and more widespread occurrence, it seems probable that the black-bear will eventually be shown to have a free vesicle stage in its embryology. If this assumption proves correct, we would then have a cycle as follows: ovulation and cleavage in June, a quiescent period lasting until the end of November when implantation occurs, followed by six or eight weeks of embryonic



EXPLANATION OF TABLE I

The table represents graphically the reproductive cycles described in the text. The first vertical mark indicates the average time when the sexes pair; this represents the time of ovulation, except possibly in the bears. The light horizontal line indicates the duration of the quiescent period (unimplanted blastocysts), the heavy line that of active development. The vertical line separating these indicates the time of implantation, the last vertical mark that of parturition.

The most obvious explanation of the facts cited above would be to assume that there exists in the black-bear an interruption of development such as has been proved to occur in other species. There is another possibility, however, which cannot be ruled out of consideration in our present state of knowledge. It may be that ovulation is delayed, and that the sperm are retained in the uterus for several months, as is known to occur in some bats. However, as only the bats are known to

development and the birth of the cubs late in January.

<i>Ursus arctos</i>	European brown-bear
<i>Ursus horribilis</i>	Grizzly bear
<i>Thalarchos maritimus</i>	Polar bear

In these species we have apparently much the same story as is found in the black-bear. The brown-bear breeds in late April, May, or June (Prell, Lönnberg) and the young are born during December, January, or February, depending appar-

ently upon the locality. The grizzly breeds somewhat later, in June or July (Seton), and the cubs are born in January. Nothing is known of what happens between pairing and parturition, except that macroscopically visible embryos are not to be found during the fall months.

The polar bear differs slightly in its time of breeding. Pairing is earlier, February to March in captive animals, and the young are born in December (Prell, Lönnberg, Heller). It is probable that conditions may influence the exact times of the cycle, as Bailey and Hendee give February or March as the time the cubs are born in Alaska.

Our reasoning in the case of these three species is the same as for the black-bear. The long interval between pairing and parturition, the small size of the cubs at birth, the failure to find embryos until near the end of the long gestation period, together with the fact that the quiescent stage has been definitely proved for four other mammals, all combine to make it probable that in these bears there exists a free vesicle period of several months duration. Actual development, on the other hand, cannot last more than six weeks or two months, judging by the size of the newborn young.

Mustela noveboracensis

Long-tailed weasel

The author has twice seen tubal blastocysts in weasels killed in northern Indiana near the end of July. At that latitude it seems unlikely that the animals could rear a second litter (the young are ordinarily born in the spring), and it is possible that these vesicles from a summer ovulation are to persist through fall and winter and develop into embryos the following spring. Warren has also raised this same question in regard to *Mustela arizonensis* in Colorado. However, we know that the closely related ferret, *Mustela putorius*, has a 40-day

gestation without any delay. As in the bears and the martens, it is necessary to have material from the fall months before the question can be settled for the American weasels.

Order Rodentia

<i>Mus musculus</i>	House mouse
<i>Mus norvegicus albinus</i>	White rat
<i>Dipodillus simoni</i>	Feral African species
<i>Meriones shawi</i>	
<i>Meriones longifrons</i>	

The five rodents listed above differ somewhat from the species previously described. In these rodents there is no delay in development when the female is not suckling young, gestation in all of them lasting normally from 19 to 22 days. In laboratory stocks, the female often breeds immediately after giving birth to a litter. If pregnancy results, the ova undergo cleavage at the usual rate, but the blastocysts do not implant, and development comes to a stop. The vesicles lie free in the uterus for from two to fifteen days, the length of the delay varying roughly with the number of young the mother is suckling. When implantation finally takes place, growth is resumed at a normal rate and the young are born at the normal stage of development, the increased length of gestation being due wholly to the quiescent period and not to any lengthening of the time of active growth.

Some of the investigators have ascribed the failure of implantation to the drain of nourishment required by the female to maintain lactation, and have tried without much success to control the length of the delay by varying the number of young suckling. Lataste, with the same idea in mind, reasoned that any depressant of the mother's well-being should cause a similar deficiency of available nutriment, and tried with some success to cause the delay by traumatizing the reproductive tract or body wall of the mother before implanta-

tion occurred. In one case, where the female was suckling young, repeated cauterization of the thigh delayed implantation for 32 days beyond the normal time. Recently Teel attempted to control implantation by the use of hypophyseal extracts; injection of these delayed implantation for as much as six days. It would seem probable that the delay is due to some effect of the hormonal conditions prevailing during lactation rather than to such a simple thing as the amount of nourishment abstracted from the blood by the mammary glands. Repetition and amplification of Teel's experiments are indicated as a promising line of attack on the whole problem of the mechanism of implantation and the cause of the free vesicle period.

The occurrence of this induced delay in wild rodents is questionable. In a fairly extensive series of examinations of mice of various kinds, free living house mice and Norway rats and wild species of deer mice and field mice, I have never found a suckling female that was pregnant. It should be noted that the three wild species which Lataste described were bred and studied in the laboratory. I am inclined to believe that copulation immediately after parturition in the mice is a response to domestication, and is rare or lacking in free living races. In this connection we may point out that Kirkham found, in his stock of mice, that many females did not ovulate immediately after parturition and that many of those that ovulated later aborted. Only about one-fifth of his mice completed pregnancy successfully while lactating.

Order Insectivora

Sorex araneus

Common shrew

In a recent paper on the reproductive cycle of the common shrew, Brambell suggests that this animal may exhibit a

delay of implantation in the lactating, pregnant female similar to what has been found in rats and mice. Brambell was led to this tentative conclusion by the large percentage of lactating females which showed free uterine vesicles as compared with the relatively smaller number of nulliparous animals containing unimplanted blastocysts. His data are admittedly inconclusive, and it will probably require observations on captive animals to settle the question.

DISCUSSION

The controlling mechanism

The problem of how delayed implantation is controlled is immensely complicated by the fact that we do not yet completely understand the mechanism of normal implantation. It is undoubtedly hormonal in action, and we do have some knowledge concerning two of the factors. We may summarize the principal points of this mechanism, as it occurs in a form without discontinuous development, before considering the possible causes of the delay. In an animal with continuous development, we find that immediately after ovulation the cells of the discharged ovarian follicle develop into a compact mass of glandular tissue known as the corpus luteum. The cells of the corpus luteum secrete into the blood a hormone which acts upon the uterus in such a way that the attachment of the ovum can be effected. That this hormone is essential for implantation is shown by the facts (1) that removal or cauterization of the corpora immediately after their formation prevents implantation; (2) that their destruction after implantation causes abortion or resorption of the ova (at least during the early part of gestation); and (3) that animals in which the corpora have been destroyed have been enabled nevertheless to go through pregnancy successfully by the daily injection of active luteal extracts.

The functioning of the corpora in turn is linked with the hypophyseal hormones and with the ovarian hormone from the Graafian follicles, but the exact way in which these hormones react on one another is not fully understood at present. Apparently the follicular hormone is antagonistic to the action of the corpus; nor can the hypophyseal hormones alone substitute for the luteal secretion, although their presence is necessary for the normal functioning of the ovary.

In the armadillo the corpus luteum grows very rapidly and attains a large size by the time the vesicle reaches the uterus. The cells of the corpus, however, do not appear to be functioning, for secretory droplets or granules are almost entirely lacking in their cytoplasm, and it is not surprising therefore that implantation does not occur. This inactive condition of the corpus luteum persists throughout the free vesicle stage. Shortly before implantation the cytoplasm of the luteal cells becomes vacuolated, with many lipid droplets, and this presumptive evidence of secretory activity is present all through the first half of the active development. Removal of the corpus luteum during this time causes abortion; its removal during the free vesicle period causes no discernible effect on the uterus or ovum. The logical conclusion is that the failure of implantation at the usual time is due to a lack of lutein secretion, and that implantation is eventually brought about by the belated activity of the luteal cells. I have no evidence as to the nature of the stimulus that eventually starts the corpus luteum functioning. This stimulus might conceivably arise within the ovary itself, although the study of scores of ovaries has failed to reveal any change except in the corpus luteum. Personally, I think that the hypophysis is the most likely place in which to look for the im-

mediate controlling agency. Attempts to shorten the duration of the free vesicle stage by the use of hypophyseal extracts or other hormones (luteal extracts, antuitrin S) have completely failed, however, so that our ideas must remain for the present purely speculative.

The corpora lutea in the American badger are quite large during the free vesicle stage; they do not undergo any noticeable change at implantation. The other species have not been studied from this standpoint; presumably they are more or less like the armadillo. In none of these cases do we have any cytological or histological studies of the ovary or corpus luteum.

Phylogenetic and ecologic relations

It may be of value to consider the distribution of delayed implantation among the taxonomic groups, and the conclusions that may be drawn as to the number of times this method of development has arisen in the mammals. In the first place, the fact that it is found in the roe-deer and is known *not* to occur in at least half a dozen other ungulates indicates that it has evolved independently in *Capreolus*. Similarly, the isolated position of the *Xenarthra* goes to show that the free vesicle stage of the nine-banded armadillo has arisen without any relationship to the other groups which show it. Since we know next to nothing of the reproductive cycles of the other *Xenarthra*, it is impossible to say whether it has evolved early, as a common feature of all the order, or of all the armadillos, or later after the differentiation into the present day genera had taken place.

The situation in the carnivores is somewhat more complicated. We have already pointed out our reasons for thinking that the bears exhibit this type of development. Since three genera of the family seem to agree closely in the details of their

reproductive cycles, it may be assumed for the present that this is characteristic of the family as a whole. In this case, delayed implantation must have arisen very early in the evolution of the Arctidae, before the differentiation into the various genera had been accomplished.

In the mustelids we find a different situation. Discontinuous development is found in three genera, but in several other genera (skunk, ferret, mink) the development is apparently continuous. This means that delayed implantation is an innovation later than the differentiation of the ancestral stock into the modern genera, and presumably is far more recent than the splitting of the carnivore stock into the bear and weasel groups. Delayed implantation must accordingly have been evolved independently in the two stocks, which with its occurrence in the armadillos and the roe-deer makes four separate occasions when this type of development has originated and become established in a species or group of species. Probably it should be five times, instead of four, for the badgers and martens are not closely related, and belong to different subfamilies. Their common possession of an embryonic delay is thus probably due to an independent development rather than to a common inheritance.

It seems to be impossible to discover any ecologic factor common to all the species showing delayed implantation. The German writers, unfamiliar with anything but the European literature, have assumed that this phenomenon was restricted to northern species exposed to a marked alternation of warm and cold seasons, and have leaned heavily on the supposed effects of the winter cold in bringing about the evolution of this habit. The occurrence of this type of reproduction in the genus *Dasyurus* (armadillos) naturally explodes that idea, for the armadillos have evolved

in South America, and it is only within the last 75 years that *D. novemcinctus* has migrated as far north even as Texas. The fact that the free vesicle stage is found in *novemcinctus* in Southern Brazil (and in *D. hybridus* in the Argentine) shows that the condition evolved in the tropics or subtropics and not during the northward migration. Also, we find other genera, sometimes closely related ones, living under the same conditions as the forms which show delayed implantation, without their reproductive cycles being affected by the environmental factors supposed to be responsible for the delay. Thus the European polecat, *Mustela putorius*, has a direct development unlike its close relatives, the martens, although it lives in the same regions and has the same habits.

Theories of the cause of discontinuous development

There have been three theories advanced to explain the reason for discontinuous development becoming the mode of reproduction in certain species. None of these, however, has dealt with all the forms, and this has invalidated most of the conclusions drawn. The three views, all advanced by German biologists, are as follows.

In his article on delayed implantation in the badger, Fries tried to explain this type of development as an adaptation for the benefit of the young. His argument was that the young need to be born as early as possible in the spring, in order that they may become old enough before the following winter to have a good chance of surviving. If the roe-deer and badger, which were the two species he was considering, had the ordinary type of development, this would require that the mating season come during the winter. Fries considered this to be an unfavorable time for the adults, due to shortage of food and to climatic

conditions, while he reasoned that in late summer or early autumn the animals should be at the height of their physical fitness. This then should be the optimum time for the rutting season. But, if the roe-deer or the badger were to become pregnant in early autumn, something had to take place to prevent the young being born during the winter, when their chance of survival would be extremely slight. In these two species this result was brought about by the interpolation of the quiescent stage in their embryology, which allowed the adults to breed when they were in best condition but postponed the birth of the young until the beginning of spring when conditions were favorable to them and at the same time did not change the duration of the actual development of the embryos. Fries thought that the bats, copulating in autumn but postponing ovulation until the following spring, were solving the same problem in a comparable manner. He does not offer any suggestion as to how this adaptive dormancy of the blastocyst may have been evolved from the usual type.

The theories of Prell as to the causes of delayed implantation are to be found in two articles (Prell, 1927b, 1930b). The second of these is in answer to Murr, whose ideas will be discussed in a subsequent paragraph. Prell's theory is based on the Pleistocene glaciation as an inciting factor; he does not seem to have known of the delay in the armadillo.

Briefly stated, his theory is as follows. Discontinuous development is found only in "old" genera, that is, genera which were in existence prior to the Pleistocene. These old groups which were exposed to the rigors of the glaciation were forced to modify their development, as the summers became so short that they found it impossible to rear their young unless these were born immediately following the long

winter season. The winters were so long, however, that if the animals bred the previous summer it became necessary for pregnancy to be lengthened so that the young should not be born during the winter. In some cases this lengthening of pregnancy was brought about by the interpolation of a quiescent period. (Prell apparently fails to discriminate clearly in all cases between lengthening of actual development and discontinuous development.) The evolution of this type of development is in the nature of an adaptive response by means of natural selection preserving the favorable variations.

There are several objections that may be raised to Prell's theory. Murr has violently attacked the ages assigned to some of the genera which Prell terms "old." Without considering any specific genus or geologic period, we may reflect that after all the genera which Prell calls "new" had ancestors living in the early Tertiary just as did his "old" groups. His "new" genera are merely groups which have changed morphologically since that time. Now it is in the highest degree unlikely that the morphological stability of a genus should be frequently associated with changes in the embryology while genera which have modified their morphology never change the type of development. We should rather expect that a new environment which necessitates a profound modification of the reproductive habits would be likely to bring about the evolution of new physical characteristics also instead of preserving the archaic type. While I am not an expert paleontologist, Prell's argument gives me the impression that he has been guilty of Procrustian methods with genera and epochs in lopping and stretching facts to fit his hypothesis. In any case, the tropical armadillo with its four-month delay nullifies his whole argument.

The last of the theories regarding discontinuous development is the idea of the direct effect of temperature upon the development. For this suggestion we are indebted to Murr. His idea is that quiescence of the ovum in the mammal is due to the same cause as in the lower vertebrates, i.e., to a lowering of the surrounding temperature. In a hibernating form, such as bear or badger (which, incidentally, may not hibernate), this is due to the fall in general body temperature. In the small martens or the thin-flanked roe-deer it is due to the animal's body being too small in proportion to its surface to prevent the reproductive tract with its contained ova, or the glands of internal secretion which control the reproductive organs, from being chilled by the winter cold! Murr has tried to vary the length of gestation in the ferret by keeping the pregnant animal under various temperatures. The differences observed were very slight, two days or less, and the number of cases (six pregnancies, counting both tests and controls) wholly inadequate. It is difficult to give any serious consideration to Murr's suggestion; the fact that in all known northern forms the delay begins in summer or autumn effectively disposes of this theory, and the case of the tropical armadillo (unknown to Murr) merely emphasizes the absurdity of the idea.

From the comments made in the preceding pages it will be seen that I am not satisfied with any of the theories so far advanced in explanation of delayed implantation. To be acceptable, a theory must take into account the following points. First, that the delay is found in species living in tropical as well as in arctic or temperate regions. Secondly, in two related genera, living in the same way and in the same region, one may show the delay and the other not; for instance, *Capreolus* and the red-deer, or the martens

and the ferret (polecat). Again, the delay begins in the summer, so that it cannot be due to any direct effect of cold or changing season; furthermore, the exact time varies in different species from May to August so that it becomes still more difficult to fix upon any stimulus common to all of the species. Similarly, the time of implantation varies from November to February and seemingly without reference to the length of actual gestation to follow; for in some species the young are born in May while in the bears they are born in the middle of winter so that the mother has to den up (not hibernate) for six weeks or more before the cubs are old enough and the weather warm enough for them to stir abroad.

When all the above points are considered, we can rule out of consideration any idea that discontinuous development is a direct response to some external stimulus. Fries' theory is, I believe, the most logical of the three considered, although the unnecessarily early birth of the bear's cubs and the somewhat tardy birth of the young of the roe-deer and the martens do not fit well into his hypothesis. In view of the difficulties of finding a purposive explanation of the process, I have wondered if possibly discontinuous development may not be a "useless character" such as is so common among morphological structures. The markings on the wings of night-flying moths, the arrangement of bristles on the thorax of a fly, the color of the plumage of a warbler—all these are characters of diagnostic taxonomic value and probably none of them has any definite survival value to the species concerned, but they have become fixed in the heredity of their possessors so that each one is now definitely characteristic of a certain species. Similarly, I can readily conceive that delayed implantation might have started as an alternative method, as it is today in some

rodents, and that the hormonal mechanism which governs it may have become fixed in the heredity of the species by accidental survival or by being closely associated with some other character which was of evolutionary importance until today the usual mechanism of development has been completely weeded out of the

hereditary potentialities of the species concerned. I know of no definite evidence either for or against this idea, but the possibility of delayed implantation being of accidental origin rather than purposive evolution should be kept in mind in considering any theory as to the meaning of discontinuous development.

LIST OF LITERATURE

- ASHBROOK, F. G., and K. B. HANSON. 1927a. Progress report of marten breeding experiments. *U. S. Dept. Agric., Biol. Survey Leaflet*, Bi-949.
- . 1927b. Breeding martens in captivity. *Jour. Heredity*, 18, pp. 498-503.
- . 1930. The normal breeding season and gestation period of martens. *U. S. Dept. Agric., circ. no. 107*.
- BAILLY, A. M., and R. W. HENDER. 1926. Notes on the mammals of northwestern Alaska. *Jour. Mammal.*, 7, pp. 9-28.
- BAKER, A. B. 1904. A notable success in the breeding of black bears. *Smithsonian Inst. Misc. Col.*, 1903, pp. 175-179.
- BISCHOFF, T. L. W. 1854. Entwicklungsgeschichte des Rehes. *Gießen*.
- BRAMBELL, F. W. R. 1935. Reproduction in the common shrew (*Sorex araneus* Linnaeus). I. The oestrus cycle of the female. *Phil. Trans. Roy. Soc. London, Ser. B*, 225, pp. 1-49.
- DANIEL, J. F. 1910. Observations on the period of gestation in white mice. *Jour. Exp. Zool.*, 9, pp. 865-870.
- DICE, L. R. 1921. Notes on the mammals of interior Alaska. *Jour. Mammal.*, 2, pp. 20-28.
- ENZMANN, E. V. 1935. Intrauterine growth of albino mice in normal and in delayed pregnancy. *Anat. Rec.*, 62, pp. 31-45.
- ENZMANN, E. V., N. R. SAPHIR, and G. PINCUS. 1932. Delayed pregnancy in mice. *Anat. Rec.*, 54, pp. 325-341.
- FERNANDEZ, M. 1909. Beiträge zur Embryologie der Gürteltiere. I. Zur Keimblätterinversion und spezifischen Polyembryonie der *Mulita* (*Tatusia hybrida* Desm.). *Morph. Jahrb.*, 39, s. 302-333.
- FISCHER, E. 1900. Zur Entwicklungsgeschichte des Dachses. *Mitt. Bad. Zool. Vereins, Karlsruhe*.
- . 1931. Die Entwicklungsgeschichte des Dachses und die Frage der Zwillingsbildung. *Verb. d. Anat. Ges., Ergänzungsheft zum Anat. Anz.*, 72, s. 22-34.
- FRISM, S. 1880. Über die Fortpflanzung von *Meles taxus*. *Zool. Anz.*, 3, s. 486-492.
- FRISM, S. 1902. Zur Nahrung, Fortpflanzung, sowie zur Schonzeit des Dachses. *Deutsche Jäger-Ztg.*, 39.
- HAIN, A. M. 1934. The effect of suckling on the duration of pregnancy in the rat (Wistar albino). *J. Exp. Biol.*, 11, pp. 279-282.
- HAMLETT, G. W. D. 1929. Delayed implantation in the mammals, and its supposed relationship to polyembryony. Abstract. *Anat. Rec.*, 44, p. 251.
- . 1932a. The reproductive cycle in the armadillo. *Zeit. f. wiss. Zool.*, 141, s. 143-157.
- . 1932b. Observations on the embryology of the badger. *Anat. Rec.*, 53, pp. 283-303.
- HELLER, E. 1930. Polar bears reared in Milwaukee. *Bull. Wash. Park Zool. Soc. of Milwaukee*, 1, no. 2.
- HERBST, G. 1873. Wann ranzt der Dachs? *Aus d. Walde*.
- . 1882. Zur Naturgeschichte des Dachses. *Zeit. wiss. Zool.*, 36, s. 471-484.
- KEIBEL, F. 1899. Zur Entwicklungsgeschichte des Rehes. *Verb. Anat. Ges., Ergänzungsheft zum Anat. Anz.*, 16, s. 64-65.
- . 1901. Frühe Entwicklungsstadien des Rehes und die Gastrulation der Säuger. *Verb. Anat. Ges., Ergänzungsheft zum Anat. Anz.*, 19, s. 184-191.
- . 1902. Die Entwicklung des Rehes bis zur Anlage des Mesoblast. *Arch. f. Anat. u. Entw.*, s. 292-314.
- KING, H. D. 1913. Some anomalies in the gestation of the albino rat (*Mus norvegicus albinus*). *Biol. Bull.*, 24, p. 377-391.
- KIRKHAM, W. B. 1916. The prolonged gestation period in suckling mice. *Anat. Rec.*, 11, pp. 31-40.
- . 1918. Observations on the relation between suckling and the rate of embryonic development in mice. *Jour. Exp. Zool.*, 27, pp. 49-55.
- LATASTE, F. 1891. Des variations de durée de la gestation chez les mammifères, et des circonstances qui déterminent ces variations. *Mém. de la Soc. de Biol.*, 43, pp. 21-31.

- LÖNNBERG, E. 1928. Contributions to the biology and morphology of the badger, *Meles taxus*, and some other Carnivora. *Arkiv. f. Zool.*, 19A, no. 26.
- MCINTYRE, W. J. 1931. Die Dachzucht. *Pelztierzüchter*, 28.
- MIRSKAIA, L., and F. A. E. CREW. 1930. On the pregnancy rate in the lactating mouse and the effect of suckling on the duration of pregnancy. *Proc. Roy. Soc. Edinburgh*, 51, pp. 1-7.
- MURR, E. 1929. Zur Erklärung der verlängerten Tragdauer bei Säugetieren. *Zool. Anz.*, 85, s. 113-129.
- . 1931. Experimentelle Abkürzung der Tragdauer beim Frettchen (*Putorius furo* L.). *Anz. der Akad. Wiss., Wien*, s. 265-266.
- NEHRING, A. 1893. Die Trächtigkeitsdauer des Dachses. *Zool. Garten*, 34.
- PATTERSON, J. T. 1913. Polyembryonic development in *Tatusia novemcincta*. *Jour. Morph.*, 24, pp. 559-684.
- PINARD, A. 1907. Gestation. Richet's Dictionnaire de Physiologie, 7, pp. 145-150 (quotation of Lataste).
- PRELL, H. 1927a. Die Paarungszeit der echten Marder. *Die Pelztierzucht*, 3.
- . 1927b. Über doppelte Brunstzeit und verlängerte Tragzeit bei den einheimischen Arten der Mardergattung *Martes* Pincl. *Zool. Anz.*, 74, s. 122-128.
- . 1928a. Rollzeit und Tragzeit der echten Marder. *Der Deutsche Jäger*, 50.
- . 1928b. Die Fortpflanzungsbiologie des amerikanischen Fichtenmarders (*Martes americana* Turt.). *Die Pelztierzucht*, 4.
- . 1930a. Bärzeit und Tragzeit des Braunbären. *Die Pelztierzucht*, 6.
- . 1930b. Die verlängerte Tragzeit der einheimischen *Martes*-Arten. Ein Erklärungsversuch. *Zool. Anz.*, 88, s. 17-31.
- PRELL, H. 1930c. Über die Fortpflanzungsbiologie der europäischen Bären. *Zool. Garten*, (N.F.) 3, s. 168-172.
- . 1930d. Über die Fortpflanzungsbiologie des Fischermarders (*Martes pennanti* Erxl.). *Die Pelztierzucht*, 6.
- . 1930e. Über die Fortpflanzungsbiologie des Silberdaches (*Taxidea Taxus* Schreb.). *Landwirtsch. Pelztierzucht*, 1.
- . 1930f. Über doppelte Brunstzeit und verlängerte Tragzeit bei den europäischen Arten der Gattung *Ursus* Linné. *Biol. Centralbl.*, 50, s. 257-271.
- . 1932. Über die Tragzeitverhältnisse beim Vielfraß (*Gale* Linné). *Zool. Anz.*, 97. (Complete bibliography of Prell's papers given in this.)
- REINHARDT, H. 1929. Beitrag zur Zucht und Jugendentwicklung des Steinmarders. *Deut. Pelztierzucht*, 15.
- RETZIUS, G. 1899. (A discussion of Keibel's paper, q. v.) *Verb. Anat. Ges., Ergänzungsheft zum Anat. Anz.*, 16, s. 65-66.
- . 1900. Zur Kenntnis der Entwicklungsgeschichte des Renntieres und des Rehes. *Biol. Untersuchungen*, N.F. 9, s. 109-117.
- SCHMIDT, F. 1928. Die Ranzzeit der Marder. *Die Pelztierzucht*, 4.
- SETON, E. T. 1909. Life-histories of Northern Animals. New York.
- TEEL, H. M. 1926. The effects of injecting anterior hypophysial fluid on the course of gestation in the rat. *Amer. Jour. Physiol.*, 79, pp. 170-183.
- WARREN, E. K. 1932. When do weasels mate? *Jour. Mammal.*, 13, pp. 71-72.
- WENDNAEGL, A. 1930. Beitrag zur Frage der Trächtigkeitsdauer des Edelmarders. *Zool. Garten*, (N.F.) 2, s. 117-120.
- ZIBOLER, L. 1843. Beobachtungen über die Brunst und den Embryo der Rehe. *Hannover*.





GENETICS AND HOMOLOGY

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GENETICS, broadly defined, is that branch of biology which deals with the origin and transmission of the characteristics of organisms. Its basic principles are three, viz., the principles of Biogenesis, Heredity, and Variation. So considered, genetics is a most fundamental branch of biology and it would be expected to throw light on all the remaining branches of biological science. This should be true, for example, for taxonomy no less than for evolution. Genetics should be able to contribute knowledge of great importance to our understanding of the problems of determining relationships.

One of the most fundamental principles of taxonomy is that of homology. Definitions and usages of homology have changed since the introduction of the term by Owen in 1843. Lankester (1870) proposed to substitute the more precise term homogeny for Owen's special homology. Mivart in the same year proposed to keep Owen's general terms homology and analogy but distinguished twenty-five sub-categories most of which were more precisely defined types of homology. Others have proposed still different interpretations and definitions to be used in describing the kinds of likenesses and differences among organisms. Naturally some biologists have felt that the general term homology was so ambiguous that its value in taxonomy was very limited. But the concept is so fundamental in the analysis of relationships that it is still widely used in spite of our inability to give it precise definition. Current usage

seems to be mainly that of Dendy (1916) that homology is "essential structural identity due to community of descent."

It is generally agreed, then, that homology is due to inheritance. Even Owen (1866) admitted that, "The most intelligible idea of homologous parts in such series is that they are due to inheritance." If so homology is a genetic phenomenon—an expression of gene action. Knowledge of gene action should therefore be able to illuminate and explain homology, and might even provide more precise criteria by which it might be recognized. The taxonomist turns hopefully to the geneticist for such a welcome contribution to the analysis of systematic affinities.

IS GENETIC HOMOLOGY A DELUSION?

Now as a matter of fact the geneticist has given little thought to these matters and that little has been mainly wrong. Take for example the brief discussion by Crew (1925, Chap. V, p. 152).

The feather of the bird is not necessarily the modified scale of a reptile but may be a distinctly different characterization based upon an entirely different genotype. A certain genotype results in a certain characterization—scales, mutation—alteration—in this genotype results in a new genotype and thus leads to another characterization. The old genotype is transformed into the new but the old characterization is not transformed, it disappears and is replaced. Scales and feathers are not homologous structures—homology attempts to establish a similarity in origin and nature of structures seemingly different and is based on the assumption that during the course of evolution structures have undergone transformation yet remain fundamentally the same. In fact this conception of homologous structures cannot be accommodated by the chromosome hypothesis until it can be

experimentally demonstrated that the genes themselves can pass through a process of gradual modification.

In a similar vein and speaking for the Mendelian, Duerden (1923-24) wrote previously, using the same illustration:

Following the older methods of comparative morphology, we can maintain that the relationship of scale and feather affords evidence that in the course of evolution the reptilian scale has grown upwards into a filament, and by a complicated system of incisions of the epidermis, due to ingrowths of the dermis, the filament has frayed out, and given rise to the many structural divisions of the feather—shaft, barbs and barbules. This is the view which has hitherto been largely accepted. . . .

But no, says the Mendelian, a feather is a new structure; it is *sui generis*: it is an epidermal mutation, the result of a separate germinal change; its origin is quite apart from that of scales. . . .

The delight of the morphologist in the tracing of a corresponding structure through all its many transitional stages, from its one extreme to the other, is but a delusion if a genetic relationship is the underlying idea.

If the above statements are true then indeed the taxonomist has little to hope for from genetics. But let us first be sure whether or no the above conclusions are correctly drawn. False conclusions have been drawn from an incomplete understanding of genetic facts. The real genetic basis of homology is the mechanism of gene action as it is expressed in the characteristics of the organism. Does the available knowledge of character determination through the action of genes make "genetic homology a delusion?" Absolutely not. Though a complete understanding of character determination through the interaction of genes will await the results of many critical experiments yet to be performed, still enough knowledge is available to make it quite clear that genetic knowledge does not make impossible the determination of homology and its application to the analysis of taxonomic relationships.

THE INTERACTION OF GENES

To understand this we need make but a brief examination of the mechanism of character determination by genes. How do genes condition the expression of inherited traits which may be homologous? The facts clearly indicate that the structure of any particular organ is determined by the interaction of many if not by all of the genes present in the particular individual. A great many examples could be given of which those in *Drosophila* are probably best known. The eye, the wing, and other similar organs and parts of the body are known to be conditioned each by many, many genes. According to Morgan, Bridges and Sturtevant (1925) more than 100 distinct genes have different specific effects upon the adult character of the wing. Over 70 are known to condition the eye. Even though each different pair of alleles may give monohybrid ratios when the wild type alleles of *all* the others are present, this does not mean that either of these whole organs is determined by a "single gene." It takes the wild type alleles of all these genes to give the wild type characters. Since 1925 many other genes affecting these two organs have been described and the end is not yet attained. There are doubtless many other genes yet to be discovered which will be shown to modify these characters, for it must be realized that when the wild type alleles are present in homozygous condition there is no way of detecting their action. One must await the occurrence of a mutation (or produce one with irradiation) which will give an allele with a non-wild type effect *in order to demonstrate the presence of the wild type gene!* The expression "single gene effect" is very misleading. We should think, even when considering monohybrid ratios, of $N + 1$ genes rather than of one gene alone. All these gene interact to gives

the end product, the adult organ. Some of the alleles influence color, some size, some shape, some the essential structure, but only rarely is the effect so marked as to change the organ so much that it can no longer be called an eye or a wing. In fact some at least of the characteristics of the eye or of the wing are shown as long as any eye or wing develops. Only in one case then, does the concept of genetic homology fail, and in that case all homology fails likewise for an organ cannot be homologous with no organ.

The position of Duerden and of Crew is then seen to be indefensible. However discontinuous the changes in individual genes may be the fact is that through the interaction of many genes the organ is still essentially and fundamentally similar. This is indeed the basis for the use of fundamental similarity in structure as a guide to relationships. It is not at all necessary that it be "experimentally demonstrated that the genes themselves can pass through a process of gradual modification," as Crew has stated. Nor can the fact that in higher organisms there may be a discontinuity of somas in successive generations be used to destroy the basis of genetic homology between the reptilian scale and the avian feather, for it leads to the absurd position that successive generations of corresponding feathers could not be homologous either. No! Genetic knowledge does not preclude the homology of the reptilian scale with the avian feather. Indeed genetic knowledge alone is capable of explaining the transformation of one to the other, and genetic knowledge may even give us more precise criteria of homology and of degree of taxonomic relationship as well. How can this be?

THE TEST OF ALLELISM

The genes are the specific hereditary units. The closest taxonomic relation-

ship would then exist between individuals of identical genotype. Taxonomic relationship in general is proportional to gene identity. This is indeed the position taken by de Vries (1910) long ago, and still soundly maintained. "Systematic relationship is based on the possession of like pangens. The number of identical pangens in two species is the true measure of their relationship." The determination of taxonomic relationships and of homology could then be based on methods of testing identity in genes. Such methods are available. Of these one is crucial, i.e., the test of allelism. Alleles are often considered to be the same genes, though the different alleles of one gene may have different effects on the same character. More precisely, the genes which are allelic to each other are of the same nature and probably of the same origin and almost always affect the same characters, though Muller (1922) has reported alleles of one gene, belonging to the truncate series and occupying the same locus, which may cause "either a shortening of the wing, an eruption on the thorax, a lethal effect, or any combination of two or three of these characters." Unfortunately the test of allelism requires actual crossing of the individuals whose genes are to be examined for their identity, and crossing of species and genera is often interfered with by intersterility. Wider crosses are possible in plants than in animals, but the typical problems of homology such as homologizing the endostyle of the tunicate or *Amphioxus* with the thyroid of the vertebrate seem beyond the reach of genetic analysis at present. However, proximate methods of less certainty are capable of aiding in the determination of homologies even in species which cannot be hybridized. For example, the demonstration that particular genes in species A have certain phenotypic expressions and

linkage relations to each other and that in species B similar genes occur with corresponding linkages and expressions would make it almost certain that the genes were identical or homologous, as Weinstein (1920) and Sturtevant (1921) have pointed out.

In conclusion therefore it may be said that genetic knowledge, far from denying the existence of real genetic homology, affirms the reality of the fundamental

similarity in corresponding structures due to heredity, called special homology, and gives in addition limited help in the determination of such homologies and in the analysis of taxonomic relationships generally. The further progress in knowledge of gene action will doubtless extend and clarify the nature of both homology and taxonomic relationships, but it is not likely that it will ever change the essential conclusions reached above.

LIST OF LITERATURE

- CREW, F A E 1925 *Animal Genetics an Introduction to the Science of Animal Breeding* Edinburgh, Oliver & Boyd 420 pp
- DE VRIES, HUGO 1910 *Intracellular Pangenesis* Eng transl Chicago, The Open Court Publishing Co 270 pp
- DENDY, A 1916 *Outlines of Evolutionary Biology* London, Constable & Co 454 pp 2nd ed
- DURDEN, J E 1923-24 *Methods of evolution* Science Progress, 18, pp 556-564
- LANKESTER, E R 1870 On the use of the term homology in modern zoology, and the distinction between homogenetic and homoplastic agreements *Annals and Magazine of Natural History*, Vol VI, Fourth Series, pp 34-43
- MIVART, St G 1870 On the use of the term "Homology" *loc cit*, pp 113-121
- MULLER, H J 1922 Variation due to change in the individual gene *Amer. Nat.*, 56, pp 32-50
- OWEN, R 1843 *Lectures on the Comparative Anatomy and Physiology of the Invertebrate Animals*, delivered at the Royal College of Surgeons in 1843 London, Longman, Brown, Green, Longmans 392 pp
- 1866 *On the Anatomy of Vertebrates*. Vol I London, Longmans, Green and Co 650 PP
- STURTEVANT, A H 1921 Genetic studies on *Drosophila simulans* III Autosomal genes General discussion *Genetics*, 6, pp 179-207
- WEINSTEIN, A 1920 Homologous genes and linear linkage in *Drosophila virilis* *Proc Nat Acad. Sci*, 6, pp 625-639





NEW BIOLOGICAL BOOKS

The aim of this department is to give the reader brief indications of the character, the content, and the value of new books in the various fields of Biology. In addition there will frequently appear one longer critical review of a book of special significance. Authors and publishers of biological books should bear in mind that THE QUARTERLY REVIEW OF BIOLOGY can notice in this department only such books as come to the office of the editor. The absence of a book, therefore, from the following and subsequent lists only means that we have not received it. All material for notice in this department should be addressed to Dr. Raymond Pearl, Editor of THE QUARTERLY REVIEW OF BIOLOGY, 1901 East Madison Street, Baltimore, Maryland, U. S. A.

BRIEF NOTICES

EVOLUTION

MODERN ANTHROPOLOGY VERSUS BIBLICAL STATEMENTS ON HUMAN ORIGIN. *Second Edition (Revised).*

By Sir Ambrose Fleming. Victoria Institute, London. 4d. 8½ x 5½; 28; 1935 (paper)
The Victoria Institute is a pious foundation, whose object it is "In humble faith in one Eternal God, Who created all things good, to combat the unbelief now prevalent by directing attention to the evidences of the Divine care for man that are supplied by Science, History, and Religion." To this end it arranges for addresses "from men who have themselves contributed to progress in Science and Research," such as the present paper by Sir Ambrose Fleming, the eminent radio engineer. This seems to have cheered English fundamentalists mightily and now appears in a second, revised edition. In it the author makes much of the fragmentary character of the fossil record of intermediate forms between the anthropoids and man. Yet, however fragmentary, these remains show that intermediate forms have existed. Nor does he take account of the many likenesses between man and the living anthropoids. As Huxley pointed out "the structural differences which separate man from the gorilla and the chimpanzee are not so great as those which separate the gorilla from the lower apes."

Another argument to which Sir Ambrose apparently attaches great importance seems to the reviewer sufficiently curious.

There is another difference between the animal and "man" to which Darwinians do not seem to have attached sufficient importance, and that is the very different value of the individual life. We consider it not wrong to kill certain animals, provided it is done without unnecessary cruelty, for food or to prevent them becoming too numerous or in self-defence, but we think that the killing of a man is only justified as an equitable punishment for wilful murder or other great crime against the community. If, then, man is merely a transformed and more perfect animal, we may ask at what stage in the evolution, and why, did this peculiar attribute of sacredness in the individual life begin? If, on the other hand, he was a special creation, and not wholly a material body, the reason for this difference is not hard to see.

Has Sir Ambrose never heard of cannibals? In truth the sacredness of human life seems to be a sentiment of comparatively recent growth in human history. In many savage tribes the mores forbid the killing of a fellow tribesman but not of a stranger. Even among Christian nations, while a foreigner is relatively safe in time of peace, it is considered a highly meritorious act to take his life in time of war.

However convincing the present pamphlet may seem to a radio engineer we doubt whether it will cause any biologist to revise his conclusion that the evolutionary hypothesis is the most satisfactory explanation yet proposed of the various graded series of fossil and living forms to be found in so many parts of the plant and animal kingdoms.



CREATION AND EVOLUTION IN PRIMITIVE COSMOGENIES and Other Pieces.

By Sir James G. Frazer. The Macmillan

Co., New York. \$3.00. 8 $\frac{1}{2}$ x 5 $\frac{1}{2}$; xi + 151; 1935.

The title essay of this collection traces some of the cosmological speculations of primitive tribes, which postulate on the one hand the creation of man by a god or on the other his evolution by a natural process out of lower forms of animal life.

So hard is it for the human mind even in speculation to strike out an absolute novelty. Perhaps in the end the two hypotheses may be found to be not so irreconcilable as at first sight they appear to be. Creative evolution or evolutionary creation, like the Pre-established Harmony of Leibniz, may after all be the expression of that great cosmic process which has wrought, and is still working, all the wonders of this mysterious universe, in its majestic progress eternally moulding the forms and directing the courses alike of atoms and of stars. Thus it would not be needful to suppose that in the ordering of the universe the divine is parted from the human by an impassable gulf.

The second essay gives a brief account of "Romulus," Marie de France, and other mediaeval imitators of the fables of Phaedrus. Others deal with Gibbon at Lausanne; Sir Baldwin Spencer as Anthropologist; Canon John Roscoe, the author of *The Baganda* and other works on the Bantu peoples; and Condorcet's *Progress of the Human Mind*. The last two essays are autobiographical and contain interesting reminiscences of Frazer's boyhood and university life.



THE COMING OF MAN. *Pre-Man and Pre-historic Man.*

By George G. MacCurdy. *The University Society*, New York. 65 cents (paper); \$1.00 (cloth); (prices slightly higher on West Coast). [Accompanying "Explanatory Reading Outline" 5 cents.] 9 x 6; x + 157; 1932.

In the earlier chapters of this book Dr. MacCurdy gives a brief account of the evolution of the primates and a more detailed description of skeletal finds of man from *Pithecanthropus* to the Cro-Magnon race and of the cultures of the Paleolithic, Mesolithic, Neolithic, Bronze and Iron Ages. In later chapters he takes up the development through the various prehistoric periods of different elements of culture, dealing with food getting; habita-

tions; fortifications; clothing, ornament and toilet; the taming of fire; art and religion; language, music and writing; labor and industry; domestication of animals and plants; transportation; commerce; the healing art; textiles and pottery; and metallurgy. This dual arrangement involves a certain amount of repetition but it has the advantage of showing the ties that bind each epoch to those that precede and follow it. An annotated bibliography of 10 titles, a glossary and a pronouncing index are also given.



THE MAGDALENIAN SKELETON FROM CAP-BLANC IN THE FIELD MUSEUM OF NATURAL HISTORY. *University of Illinois Bulletin*, Vol. 32, No. 34. *Illinois Medical and Dental Monographs*, Vol. 1, No. 1.

By Gerhardt von Bonin. *University of Illinois, Urbana*. \$1.00. 11 x 8; 76; 1935 (paper).

This is a qualitative and quantitative description of the Magdalenian skeleton uncovered in 1911 at Cap-Blanc. It possesses the distinction of being the one-skeleton of its period to be under the care of an American institution. It is rather complete, although the skull was somewhat damaged and required considerable reconstruction. In summary, it is the skeleton of a young female of about 20 years of age and of about 156 cm. in stature. There are no anthropological contraindications to its being accepted as belonging to the Upper Paleolithic period. The descriptions are as complete as could be expected and whenever possible the author has included comparative data on the measurements of other skeletons of the same period.



FOSSILS. *What They Tell Us of Plants and Animals of the Past.*

By Richard S. Lull. *The University Society*, New York. 65 cents (paper); \$1.00 (cloth); (prices slightly higher on West Coast). [Accompanying "Explanatory Reading Outline" 5 cents.] 9 x 6; viii + 114; 1935.

This introduction to the study of fossils is

thorough and at the same time briefly and interestingly written. The author discusses the nature of fossils, how they are formed, locations in which they are to be found, what the different geological strata yield, and finally the last chapters are devoted to the more highly specialized fossil forms such as the horse, elephant and mastodon, and men. There are many free hand drawings and also photographic illustrations.



THE COMING AND EVOLUTION OF LIFE.
How Living Things Have Come To Be As They Are.

By Henry E. Crampton. *The University Society*, New York. 65 cents (paper); \$1.00 (cloth). (Prices slightly higher on West Coast). [Accompanying "Explanatory Reading Outline" 5 cents]. 9 x 6; vi + 103; 1931.

In the first part of this book Dr. Crampton gives an excellent résumé of the evidence for organic evolution from comparative anatomy, embryology and paleontology. In the last chapter he deals with the factors of evolution, concluding that Darwin's formula of the natural selection of congenital characteristics is corroborated by all of the discoveries up to the present time. An annotated bibliography of 18 titles, a glossary and a pronouncing index are given.



REMARQUES SUR L'ÉVOLUTION DES DENTS MOLAIRES CHEZ LES MAMMIFÈRES. *Actualités Scientifiques et Industrielles* 176. *La Paléontologie et les Grands Problèmes de la Biologie Générale*, III.

By Étienne Patte. *Hermann et Cie*, Paris. 12 francs. 10 x 6½; 49; 1934 (paper).

The author briefly discusses the tritubercular theory of the evolution of molar teeth as modified by Gregory. The main purpose of the monograph is to answer the more recent criticisms levelled at this theory. The author therefore reviews the latest paleontologic observations; he is led to conclude that Gregory's hypothesis has been so far confirmed rather than disproven.

GENETICS

THE PRINCIPLES OF HEREDITY.

By Laurence H. Snyder. *D. C. Heath and Co.*, Boston. \$3.00. 8½ x 5½; xiii + 385; 1935.

There are certain technicalities of genetics which make it a difficult subject to write about. In this book, the author seems to have bridged a number of these difficulties and, in consequence, has produced a readable and understandable text. The book is conventional in its organization, developing the cytological, breeding and biometric aspects of heredity. Human variations have been used as much as possible to illustrate the mechanism of inheritance. A welcome addition to biological textbooks.



INTRODUZIONE ALLO STUDIO DELL'EUGENICA (*Eredità Biologica*).

By Giuseppe Cristalli. *Stabilimento Industrie Editoriali Meridionali*, Naples. L. 15. 9 x 6; 219; 1934 (paper).

This is an outline of genetics which, though intended for the layman, is superior to the general run of science popularizers. As an introduction to the subject, the author gives a summary description of the gonads and of the mechanism of reproduction. There follows a satisfactory presentation and critical discussion of the various theories, from pangenesis to mutation. Throughout this work the author manifests a healthy scepticism regarding these theories and he apparently takes great pleasure in pointing out the specific weaknesses and lack of factual proofs.



HEREDITY AND VARIATION. *Continuity and Change in the Living World.*

By L. C. Dunn. *The University Society*, New York. 65 cents (paper); \$1.00 (cloth); (Prices slightly higher on West Coast). [Accompanying "Explanatory Reading Outline" 5 cents]. 9 x 6; vi + 120; 1934.

This discussion of heredity and variation begins with a summary of Mendel's work, giving many illustrations to show the results of crossing pure and hybrid stocks.

The mechanism of heredity is treated in the usual manner. Subsequently the following topics are discussed: Variation, application of genetics to evolution, application of genetics to husbandry, inbreeding, outbreeding, applications to human society, heredity and environment, and what we inherit.



GENERAL BIOLOGY

GESTALTLEHRE DES LEBENS UND DER RASSE.
Lösung der Krise in der Medizin und Hygiene.
 By Igo Kaup. Johann Ambrosius Barth,
 Leipzig. 7.50 marks. 9½ x 6½; vi +
 154; 1935 (paper).

This arresting study presents the results of statistical, anthropometric, and experimental investigations concerning the problems of life, which the author pursued for a period of almost fifteen years. He finds that a real solution of the problem cannot be reached on the basis of a causal mechanism nor a vitalistic entelechy, but only through the concept of *Gestalt* (structure). The idea that "Gestalt, not matter is the fundamental principle of life" is not a new one. Its history has included the thinking of some of the greatest biologists who have ever lived. Kaup contends that just as the free order of elementary acts in "structures" and "forms" of the new physics has superseded the rigid order of Euclidian geometry and the *Weltbild* of the "classical" physics, so likewise these same concepts will prove to be the basis for a more profound understanding and a more satisfactory solution of the perplexing problems confronting the sciences of life—biology, medicine, hygiene, psychology, etc. A true biocentric world view of the realities of life will in his view thus supplement the new physical *Weltbild*. Otherwise expressed, it concerns the problem of the biological similarity of the individuals of species and races and the problem of the relationships of all the functions and stimuli of life to the totality; hence also to the problem of the body-soul unity.

Specifically, the author discusses: (1) biological similarity, morphologically and functionally considered; (2) experimental work on physiological functions

and stimuli; (3) application of a *Gestalt* theory to biological, medical and hygienic problems, including such topics as *Gestalt* and heredity, *Gestalt* and hygiene inclusive of natural cures, race, domestication, and population problems, the declining birth rate, and talent and mental disease; *Gestalt* and medicine (pathology); (4) *Gestalt* and the *Geisteswissenschaften*, including the sociological and political sciences, and educational reform.



LIMNOLOGY.

By Paul S. Welch. McGraw-Hill Book Co., New York. \$5.00. 9 x 5½; xiv + 471; 1935.

There is a very good chance that this volume will prove to be the most important new textbook published this year because it appears at a time when the science it expounds is still in a formative state, still susceptible to the influence of a critical and informative survey such as this. There is an increasing interest in the life of inland waters, both lakes and streams, and the fact that it is a field of ecology in which the quantitative methods of chemistry, physics, and physical chemistry can be used to supplement the methods of several of the biological sciences is enough to insure that still more workers will be attracted. Fundamentally, this text has three objectives: to indicate the nature of the information that is already available and by means of an excellent classified bibliography covering 54 pages to make the original data accessible; to examine the logical implications of this information; and to indicate the gaps that arise when this information is fitted into a logical system.

The text is clearly written and is free from ambiguity. There are numerous quotations, tables, definitions, and opinions, taken from research publications which are fitted into the text in a coherent way. In short, it is the kind of writing that is a tacit invitation to further observation and research, and this is the best recommendation for a textbook intended for graduate students, after all. The excellent index covers 20 pages.

AN ALMANAC FOR MODERNS.

By Donald C. Peattie. G. P. Putnam's Sons, New York. \$3.00. 8 x 5; 396; 1935.

This is a collection of thumb-nail essays mainly about the natural history of the region about Washington, D. C., arranged in an around-the-year day-by-day form. The general effect is not dissimilar to what might be expected to result if one were to stew in the same pot Gilbert White, John Burroughs, Thoreau and Emerson, and then dilute the *residuum*. The author has a considerable literary talent, of which he appears to be not wholly unconscious. The book makes pleasant reading for otherwise unoccupied *lacunae* in the space-time continuum (we read it in a deck chair in mid-ocean). Its biology is generally sound and often acutely shrewd. There is also a fair amount of a simple, homely philosophy of life and living that is refreshing in these addled times.



ESSENTIALS OF TISSUE CULTURE TECHNIQUE.

By Gladys Cameron. Illustrations and Chapter on Photomicrography by C. G. Grand. Farrar and Rinehart, New York. \$3.00. 9 x 6; xvi + 134; 1935.

This book should fill the important need for a succinct, readable and understandable account of the tissue culture technique. The author presents her material clearly, and commendably discusses the sort of lowly problems that puzzle the beginner, such as what instruments should be used, what are the formulae for specific solutions, how the apparatus should be arranged, etc. The book is *sensu stricto* a laboratory guide and an interesting one. There is a foreword by Robert Chambers.

GENERAL BIOLOGY. *A Textbook for College Students.*

By Henry R. Barrows. Farrar and Rinehart, New York. \$3.50. 8½ x 5½; xvi + 624; 1935.

A textbook designed to meet the needs of a full year course in elementary college biology. It aims to enrich the cultural background of the general student as well

as to furnish the basic materials required for further biological work. The volume is well illustrated and indexed. In the appendix will be found sections on the vitamins, a classification of organisms, short biographies of eminent biologists, and a list of reference books.

PARASITES ET PARASITISME.

By Pierre P. Grassé. Armand Colin, Paris. 10.50 francs (paper); 12 francs (cloth). 6½ x 4½; 224; 1935.

This booklet is intended for the use of medical students, physicians and others not specializing in parasitology. It is not in any sense a textbook but rather a critical discussion of the complex and diverse aspects of parasitism which the author illustrates with numerous examples. The subject matter includes chapters on the morphologic peculiarities of parasites and their significance; on the different forms of relationship between parasites and hosts; adaptation, immunity, etc. Within its limits it is a good and informative work especially useful for the general biologist, because the author has made a conspicuous effort to integrate parasitic and non-parasitic means of existence.



DEUTSCHES BIOLOGEN-HANDBUCH.

Edited by Ernst Lehmann, in collaboration with Dr. Härle, Dr. Hoss, and Dr. Mittermann. J. F. Lehmann, Munich. 3.75 marks. 7½ x 4½; 227; 1935 (paper).

This useful little book contains: a directory to the schools, research institutions, experiment stations, museums, and societies devoted in whole or in part to the biological sciences in Germany—including name of director and, in some cases, number of personnel; a list of journals and year-books useful to biologists; list of members, with addresses, of the Deutscher Biologen Verband. There is an index of place names.



THE SMALLEST LIVING THINGS. *Life as Revealed by the Microscope.*

By Gary N. Calkins. *The University Society, New York.* 65 cents (paper); \$1.00 (cloth). 9 x 6; viii + 135; 1935. This is a small but accurate survey of the Protista by a competent investigator. The author reviews the general biology, with a minimum of technicalities, of the filterable viruses, bacteria, spirochaetes, and protozoa. There are also discussions about the nature and organization of protoplasm. Drawings and photographs add to the book's value.



ON THE SEASHORE.

By L. R. Brighwell. *Thomas Nelson and Sons, New York.* \$1.00. 7½ x 5½; viii + 119 + colored plate; no date [1935]. An entertaining little book written for the amateur collector, and vacationist at the seaside. The life habits of various of the simple forms of sea life are discussed. The illustrations are drawn free-hand by the author. This will certainly interest the person who has had no biological training and wishes to know something of the thousands of curious animals he sees on the beach.



HOLIDAY SHORE.

By Edith M. Patch and Carroll L. Fenton. *The Macmillan Co., New York.* \$2.00. 8 x 7½; x + 150; 1935. In this book Dr. Patch, the author of *Holiday Pond*, *Holiday Meadow* and *Holiday Hill* (previously reviewed in *THE QUARTERLY REVIEW OF BIOLOGY*), aided by Dr. Fenton's charming drawings and photographs, writes of hungry *Aster*, the starfish; *Spiny*, the green sea urchin; *Loligo*, the squid; *Limulus*, the king crab, and many other interesting animals that live in or by the sea. Delightful introduction to seashore fauna for children between four and ten.



TEXTBOOK OF BIOLOGY.

By E. R. Spratt and A. V. Spratt. *University Tutorial Press, London.* 9s. 6d. 7½ x 4½; viii + 646; 1935. A textbook on biology by the same

authors has already been noticed in this *REVIEW* (Vol. 10, p. 91). This book differs from the previous text only in being more elaborate and more fully illustrated. The same principles of teaching are held to as in the earlier text.



URDEUTSCHLAND. *Deutschlands Naturschutzgebiete in Wort und Bild. Lieferungen 7, 8, 9, 10.*

By Walther Schoenichen. *J. Neumann. Neudamm.* 2 marks each. 10½ x 8½; Lief. 7, 145-168 + 9 plates; Lief. 8, 169-192 + 9 plates; Lief. 9, 193-216 + 9 plates; Lief. 10, 217-240 + 8 plates; 1935 (paper).

Previous numbers of this beautifully produced and illustrated work were noticed in the June number of this volume of the *REVIEW*. The present numbers are devoted to geological formations in Germany.



BULLETIN DE L'ASSOCIATION DES DIPLÔMÉS DE MICROBIOLOGIE DE LA FACULTÉ DE PHARMACIE DE NANCY, No. 10.

Faculté de Pharmacie, Laboratoire de Microbiologie, Nancy. 9½ x 6½; 48; 1935 (paper).

A REVISED LIFE-ZONE MAP OF CALIFORNIA. *University of California Publications in Zoology, Volume 40, Number 7.*

By Joseph Grinnell. *University of California Press, Berkeley.* 25 cents. 10½ x 6½; 3 + 1 map; 1935 (paper).



HUMAN BIOLOGY

EPIDEMICS AND CROWD-DISEASES. *An Introduction to the Study of Epidemiology.*

By Major Greenwood. *The Macmillan Co., New York.* \$5.50. 8½ x 5½; 409; 1935.

In this volume the Professor of Epidemiology and Vital Statistics in the London School of Hygiene and Tropical Medicine has permitted his wide knowledge, ripe wisdom, and consummate literary talents to play over a far-flung range in the field of epidemic diseases. The treatise is not

very systematic as dull textbooks are; pedantry is completely absent from its pages; the profound scholarship that underlies it is not apparent—indeed the author's modesty has led to its painstaking concealment. It is expressly not intended as a textbook in our sense, but to inform the wider circle of persons interested "in the communal aspects of health and disease."

The book divides itself into two parts. The first, of nine chapters, treats of general principles and methods, and is essentially a short "history of ideas" about epidemic diseases. It is delightfully written, and its incisively critical attitude is its chief and best feature.

The second and longer part of the book deals with some thirteen important diseases of which cancer is one, as illustrations of the application of general principles of science, and their results. Here the technique of presentation, while still predominantly historical, has some of the characteristics of the detective story at its best.

It is impossible in the space available justly to review this important book—probably the most important book on the general principles of epidemiology, all things considered, that has appeared in a generation. We therefore attempt only to bring it to the notice of our readers with an unqualified recommendation. No student of any aspect of public health can afford not to read it, study it, and then ponder over it.



THE GEOGRAPHIC PATTERN OF MANKIND. *Students' Edition.*

By John E. Pomfret. D. Appleton-Century Co., New York. \$3.00. 8½ x 5½; xv + 442 + 21 plates; 1935.

This is a volume of first-rate importance to every student of human biology. The preface implies that it is, directly and indirectly, an outcome of a survey course in social science given to Princeton undergraduates. Its aim is to describe in a logical and orderly way the environment of man, as he now exists on this globe. The audience for which it is primarily intended is the student of politics, eco-

nomics, or sociology. It endeavors to describe such relationships as are definite between the "natural landscape" and the "cultural landscape" in various regions of the world. Taking it as a whole the author has done a superb job.

The first four chapters deal with some of the basic laws and principles of the science of geography, particularly those relating to climate. The following eleven chapters are concerned with detailed descriptions of types of environments and geographic regions.

The book is intelligently and significantly illustrated with 15 text figures and 21 plates. There is a short (much too short in fact) list of "Selected Reference Works" in lieu of bibliography, and a detailed index.



THE MUSICAL INSTRUMENTS OF THE NATIVE RACES OF SOUTH AFRICA.

By Percival R. Kirby. Oxford University Press, New York. \$12.00. 10 x 7½; 296; 1935.

Both the ethnologist and the musicologist will find a valuable addition to his source material in this extremely thorough piece of research into the music and musical instruments of the native peoples of South Africa. The investigation was aided by a generous grant from the Carnegie Corporation. In its course the author, who is professor of music in the University of Witwatersrand at Johannesburg, brought together a unique collection of the native instruments and of photographs of the natives playing them. Every choir of the orchestra is represented; there are strings, woodwinds (both flutes and reeds); brasses (though most of the horns are really "horns" rather than metal surrogates), and percussion, including xylophones. And for good measure there is the "gora," a stringed-wind instrument that is *sui generis*. Musical examples given in profusion throughout the book show that the native music is pretty primitive by our standards. But it is interesting to note that in Bechuanaland the natives go in for reed-flute ensembles, with as many as twenty or more performers in the band, with the instruments tuned in different keys.

The book is extensively documented, beautifully printed and illustrated, and well indexed. It is a contribution of first-rate importance.



AFTER THREE CENTURIES. *A Typical New England Family.*

By Ellsworth Huntington and Martha Ragsdale. *The Williams & Wilkins Co., Baltimore.* \$2.50. 7½ x 5½; viii + 274; 1935.

This book reports the result of a very interesting attempt to study the influence of heredity on individual social and economic status. This investigation centered around the descendants of "Simon Huntington, a Puritan emigrant from eastern England, who died of smallpox at sea in 1633 and whose widow landed at Dorchester with four young sons and a daughter." They settled in New England and there the family achieved wealth and position; until more recent years they intermarried only with similar Puritan stock. The authors have traced the present descendants of this family and compared their social and economic status with that of the general population of the United States. In addition, they have selected representative Puritan surnames, certain widespread English surnames and some common non-English (Irish, German, Scandinavian, Italian and Jewish) surnames and compared the relative frequencies with which these surnames are mentioned in the different Who's Who, professional directories, etc., their ratings in Dun and Bradstreet's, and finally their incidence in the social service exchange and criminal identification lists. The results of these two orders of investigations are: (a) that the Huntington family in general occupies a higher social and economic position than the general population; (b) that on the average the Puritan surnames rank higher than the English and these higher than the non-English surnames. It is unfortunate that the authors have not tested the first findings to determine whether it is not due to sampling error. To give any definite meaning to second findings it would be necessary to place the surnames on a

comparative basis relative to the time of individual immigration here.

The author's conclusions appear to be that given the right climatic conditions judicious selection and segregation will produce a superior people and to this especially he attributes the higher position of the Huntington and old Puritan families. There is a chapter entitled "What might have been" which does not belong in a book of scientific pretensions. The authors think that if after colonial days there had been no further immigration, the United States would be as a whole in better social and economic conditions! Is it to be presumed that the old Puritan families would have invented a genteel way of mining coal or laying railroad tracks or making steel rails?



THE POETRY OF JOSÉ MÁRMOL. *The University of Colorado Studies, Volume 22, Numbers 2 and 3.*

By Stuart Cuthbertson. *University of Colorado Studies, Boulder.* \$2.00. 10 x 6½; 193; 1935 (paper).

In spite of the doctrine of pan-Americanism the people of the United States for the most part know little of the culture of their Latin American neighbors. In 1865 Sarmiento wrote from Boston that "Mr. Longfellow, who is considered the most notable English poet of the epoch and who has an excellent knowledge of Spanish, lamented that he did not know any of the poetry of our country, and Mr. Ticknor, who is now perhaps the foremost Spanish critic and scholar, although he is a North American, showed the same regret. . . ."

In the seventy years since this letter was written the North American knowledge of South American literature has not increased greatly. Nevertheless a certain amount of work is being done, to which Professor Cuthbertson's scholarly study of one of the principal Argentine poets is a welcome addition.

For half a century after the establishment of Argentine independence the country suffered from the ill feeling between the urban population of Buenos Aires and the gauchos of the pampas. In 1835

General Rosas, the idol of the gauchos, of whom Darwin gives a vivid sketch in his *Voyage of the Beagle*, became dictator and proceeded to quell opposition by killing or exiling his opponents. Among the exiles was Mármol, a young intellectual who spent the twelve years until Rosas' overthrow in Montevideo and Rio de Janeiro, pursuing his multitudinous love affairs and writing invectives against his arch-enemy as well as other poems and novels. Upon Rosas' downfall he returned to Argentina and renounced literature for a political career.

In this careful study of Mármol's poetry Professor Cuthbertson concludes that most previous critics have overemphasized his political invectives, whereas his real importance is as a poet of nature, love and God. He concludes also that Mármol is far more cosmopolitan than Spanish in his literary origins and that he is one of the outstanding romanticists of Spanish-American literature.

In the bibliography of four pages Byron twice appears as "Alfred Lord Byron." Evidently Professor Cuthbertson has inadvertently confused him with another poet-peer who wrote of Sir Galahad rather than of Don Juan.



PARETO'S GENERAL SOCIOLOGY. *A Physiologist's Interpretation.*

By Lawrence J. Henderson. Harvard University Press, Cambridge. \$1.25. 8 $\frac{3}{4}$ x 5 $\frac{1}{2}$; viii + 119; 1935.

This essay by one who has long been an ardent student of Pareto's theory of general sociology well serves as an introduction to the English translation of this important work which has recently appeared. Few will ever get further than these pages but the serious student will be all the more keen after pondering at length over residues, derivations, sentiments, non-logical actions, equilibrium, etc., to turn to Pareto's *Treatise*.

Briefly the *Treatise* deals with the development of a systematic method of approaching sociological inquiry. It calls for a study of the non-logical activities of individuals, for, according to Pareto, only when such a study has been made is it

possible to determine the part played in human affairs by logical reasoning. About half of the present volume (59 pages) is devoted to the essay. The author uses Willard Gibbs' generalized description of a physico-chemical system, which has long served theoretical science, as an illustration of what Pareto's conceptional scheme of the social system means for sociological investigation. In the latter part of the volume will be found a series of lengthy notes (13 in all) discussing Pareto's use of terms, sources of his ideas, etc. Henderson believes that "acquaintance with Pareto's analysis of facts, with his synthesis of results, with his methods, and with some of his theorems is at present indispensable for the interpretation of a wide range of phenomena, whenever and wherever men act and react upon one another." The volume is without index.



FRONTIER FOLKWAYS.

By James G. Leyburn. Yale University Press, New Haven. \$3.00. 9 $\frac{1}{4}$ x 6; x + 291; 1935.

A book of great interest to the general reader and to the student of social science. When people of an established order go to frontier countries in what way do they readjust themselves to their environment? How does contact with uncivilized man and the hardships which a strange and rude country thrust upon them tend to alter the mores of a group of people? Eight frontiers are discussed: The Massachusetts Bay Frontier (1629-1650); The French along the Saint Lawrence (1660-1698); New Zealand: a Frontier Founded upon a Theory (1839-1857); Portuguese Settlement Plantation Frontier in Bahia, Brazil (1549-1580); The Frontier of the Pastoral Boers in Transvaal (1835-1899); Two Frontiers in Australia (1787-1840); The Dutch Exploitative Frontier in Java; Economic Adjustments on Spanish Frontiers.

In all of these the author finds that there had been "a cultural retrogression to something primitive." In the Massachusetts colony primitive religious faith and practices appeared among the Puritans. In Canada, where there was an adaptation

of the seignorial system of France, contact with the Indians had a profound effect on the economic, political and social life of the communities. New Zealand was founded upon the theory that the only proper colonists are those who are carefully selected as to age, character and health. Definite economic principles were established for the colony before it departed from England but most of these were dropped as unworkable in the new environment. After eight years of distress the communities gradually emerged with modified mores and institutions. Each frontier had its own interesting problems which the writer skilfully depicts. The final chapter is devoted to a discussion of the study of frontiers in relation to the science of society. The volume is abundantly documented and is indexed.



THE COSMIC WAY TO TRUE CIVILIZATION THROUGH PARENTHOOD.

By George H. Donahue. [No place of publication]. 9 $\frac{1}{8}$ x 6 $\frac{7}{8}$; 68; 1934 (paper). Dr. Donahue in his foreword relates how Socrates, while serving as an Athenian soldier "found his feet rooted to the ground in the camp of the Greek army. Thus pinned to the earth he remained for twenty-four hours in a trance,"—one wonders what his sergeant said—"the body suddenly reduced to impotence, the spirit caught up into regions whither no eye could follow it." During this trance "THE COSMIC WAY" was revealed to him. This Cosmic Way Dr. Donahue proceeds to expound. The exposition winds its devious course through the discovery of the voltaic cell, Aristotle, Priestly, Lavoisier, Dalton, Mendelejeff and the periodic table of the elements, Newton's studies in optics, Fraunhofer (*sic*), Bunsen, Kirchoff, Thomas Young, and Sir J. J. Thomson to the conclusion that

Children must be inspired to realize that the cosmic conditions of our human existence make it impossible for anyone else to do for us what we alone can do and ought to do; that we cannot do for others what they alone can do and ought to do; that if we do not what we can do and ought to do, what we can do and ought to do remains not done; that they serve

best who are best by being best; that they sacrifice most, and most inimically, who least attain; that BE and BECOME is the mandate of Religion and of Science; that Religion imparts the illimitable upward urge; that pure Science, the personal potential becoming actual in each one of us, alone can tell us how RIGHTLY to watch our footsteps; that "The Kingdom of God" is within us and is self-establishable only; that "The Golden Rule" of right conduct must become—if Democracies are to become safe for Civilization—

ALL THINGS WHATSOEVER YE WOULD THAT MEN SHOULD BE TO YOU, BE YE EVEN SO TO THEM.



UN AMI DE STENDHAL, VICTOR JACQUEMONT.

By Pierre Maes. Desclée de Brouwer et Cie, Paris. 30 francs. 8 x 5 $\frac{1}{2}$; xii + 642 + 10 plates. no date.

In this interesting biography M. Maes tells the story of a young French naturalist of the early nineteenth century. Victor Jacquemont's father was a member of the *Conseil de l'Instruction publique* and a Tribune under the First Republic, a member of the Institute and a friend of Destutt de Tracy, Cabanis and La Fayette. Victor had the entrée of the Parisian salons where he became the friend of Stendhal and Mérimée. M. Maes proves that he collaborated in the writing of *De l'Amour*.

But, though Jacquemont might show himself a master of the theory of love, he was not equally successful in its practice. An unrequited passion led him to seek forgetfulness in America. Fresh from the salons of Paris and not a little homesick, he found few things in the New York of 1826 to please him. "The Bible," he wrote to one of his friends, "seems to me to be the scourge of America. . . .

"What I have seen in the United States has made me renounce the opinion that religious ideas can be a moral instrument useful to human societies. I have long inclined to believe it but I believe it no longer.

"Everyone here gives *all* his time to making money. . . .

"A very rich man can scarcely be convicted of anything short of murder; he buys impunity for all other offenses against society. Is it from the judges or

the juries? The public often replies: 'From both.' "

His stay in America was interrupted by the offer of the *Muséum d'Histoire Naturelle* to send him on a collecting trip to India. His experiences here were narrated in his *Voyage dans l'Inde*. Unfortunately, a promising career was cut short by his death at Bombay at the early age of 31.

The book contains a bibliography of 19 pages and an index.



AN INTRODUCTION TO THE ANTHROPOLOGY OF THE NEAR EAST IN ANCIENT AND RECENT TIMES.

By C. U. Ariëns Kappers. With a Chapter on Near Eastern Bloodgroups, by Leland W. Parr. N. V. Noord-Hollandsche Uitgeversmaatschappij, Amsterdam. \$9.00. 10½ x 7; vii + 200 + 2 folding plates; 1934.

In this monograph Professor Kappers publishes a comprehensive anthropological survey of the several population groups of the Near East and Dr. Parr contributes information on their blood groups. The senior author has gathered together numerous data on the cranial index of the skulls found in these regions and on the cephalic index of the present inhabitants. He supplements this with a summary of archeological and historical details regarding origin, migrations and intermixtures of these peoples. The anthropological data are mostly presented in the form of frequency curves, the majority of which are plurimodal. To this fact the author attributes a certain importance and appears to regard the plurimodality as the sign of specific racial mixtures. This may be so, yet the usual statistical test when applied to a few curves (continuous curve, p. 7; continuous and dotted curves, p. 9; dotted curve, p. 10) reveals that the secondary modes may be due to chance fluctuations. It is to be deplored that the author has not employed more refined statistical analysis in order to throw some light on this and other points that he makes. This publication is in every other respect an important contribution to anthropologic literature.

INSTITUTIONAL TREATMENT OF DELINQUENT BOYS. Part 1. Treatment Programs of Five State Institutions. U. S. Department of Labor, Children's Bureau Publication No. 228.

By Alida C. Bowler and Ruth S. Bloodgood. U. S. Government Printing Office, Washington. 25 cents. 9½ x 5½; v + 324; 1935 (paper).

This is the first part of a report on an investigation made to determine how effective has been the work of some public institutions in educating delinquent boys. It presents a detailed description of the buildings, equipment, quality of personnel, training programs, etc., as observed in five state institutions: Whittier State School, Whittier, Calif.; Boys Vocational School, Lansing, Mich.; State Home for Boys, Jamesburg, N. J.; New York State Agricultural and Industrial School, Industry, N. Y.; Boys' Industrial School, Lancaster, O. It is surprising to note how different are the methods of training in these institutions that have theoretically one and the same objective. In this reviewer's opinion the most striking feature which emerges from this and similar reports is the incongruity between the high ideals of modern penology and the lack of the proper qualifications in the personnel of some of these institutions. The second part of this work will be awaited with interest. It will report on the subsequent career of a selected group of boys discharged from these and other institutions.



DIE RASSEN DER MENSCHHEIT.

By Hans Weinert. B. C. Teubner, Leipzig. 4.60 marks (paper); 5.60 marks (cloth). 9½ x 6½; vi + 139; 1935.

In the first few pages of this book the author discusses the origin of man and places the time of the splitting off of *Homo sapiens* from the chimpanzee stock in the Pliocene age. The rest of the book is a discussion of prehistoric man and the anthropological and ethnological characteristics of the present races and representative sub-races of man. The author is admittedly unable to elucidate the problem of the time, place and manner the separate forms from which the white,

negro and yellow races developed, split off from each other. The book is well written and illustrated, and there is a short bibliography of German titles.



BIRTH CONTROL IN ASIA. *A Report of a Conference Held at the London School of Hygiene and Tropical Medicine, November 24-25, 1933.*

Edited by Michael Fielding. Birth Control International Information Centre, London. 5 shillings. 8½ x 5½; 101; 1935.

At the three sessions of the Conference, at which Lord Horder presided, the following subjects were discussed: Population problems in the East; The standard of living in Asia; and The practical problems of contraception in the East. The main papers which are reported in full are by Professor A. M. Carr-Saunders (England), Dr. Rajain Kanta Das (India), Mr. V. K. Krishna Menon (India), Professor H. H. Chen (China), Mr. P. K. Wattal (India), Leonard S. Hsu and Ch'eng-Hsiu Chao (China), Dr. Helena Wright (England) and Dr. Kato (Japan). Included in the report are discussions of the papers presented by other members of the conference. The volume is indexed. Michael Fielding [a pseudonym] contributes the preface.



INTERNAL MIGRATION IN THE UNITED STATES.

By C. Warren Thornthwaite. Assisted by Helen I. Slentz. University of Pennsylvania Press, Philadelphia. \$1.00. 10 x 6½; x + 52 + 9 plates; 1934 (paper).

By utilizing population census data, certain vital statistics and school data the author is able to trace the main currents of interstate migrations in the United States and of intrastate population movements for a few selected states. The method of analysis and the graphic representations of the data are ingenious and interesting. However, there is little new in the broad facts shown: viz., that main currents of migration have been from east to west, from rural to metropolitan areas (reversed in 1929), from south to north for the negroes, and in general to wherever

the economic possibilities appear more alluring.



APPLYING SCIENCE TO AGRICULTURE. *Report of Director of Oklahoma A. and M. College, Agricultural Experiment Station, for July 1, 1932, to June 30, 1934.*

By C. P. Blackwell. Oklahoma A. and M. College, Agricultural Experiment Station, Stillwater. Free. 8½ x 5½; 318; 1934 (paper).

This report from the Oklahoma Agricultural Experiment Station is a most thorough and comprehensive survey of the experimental work done in the station for the past two years. There is a foreword by the director discussing the need for experimental work, particularly in the field of soil erosion; more than 75 per cent of Oklahoma soil is eroding badly. The report is divided into sections on soil and crop investigations, livestock investigations, poultry problems, dairy problems, chemistry in agriculture, economic and social studies, horticultural investigations, insect pest studies, and plant disease studies.



SOME THOUGHTS OF A DOCTOR.

By Frederick P. Weber. H. K. Lewis and Co., London. 6 shillings net. 8½ x 5½; 183; 1935.

These essays, by a distinguished English physician, reveal a delightful personality and the mind of one who has attained a real philosophy of life. The papers, many of which have already appeared in the medical press, cover a wide range—eugenics, free will and heredity, the gambling spirit, thoughts about thinking and dreaming, extravagance in Freudian teachings, suicide and euthanasia, Samuel Butler's theories of cell memory, nature and God, etc. Sir W. Langdon Brown contributes a foreword. The volume is without index.



FIFTY-SIX YEARS A MISSIONARY IN CHINA. *The Life of Mother St. Dominic, Helper of the Holy Souls.*

[Anonymous]. [According to dust cover by Mother St. Austin, H. H. S.] *With a Preface by Archbishop Goodier, S. J., and a Foreword by The Bishop of Nanking. Burns Oates and Washbourne, London.* 5 shillings. 7½ x 4½; xix + 249 + plate; 1935.

This story of the life of a missionary nun in China is concerned less with her actual experiences among the Chinese than with her saintliness. The author, a companion of the Mother for many years, writes largely of the religious thoughts and mental struggles of the nun and of her influence on the novices, giving many direct quotations from the large mass of notes and records which she left. The volume is without index but contains a few illustrations.



GEBURTENRÜCKGANG. *Mahnruf an das deutsche Volk.* 3. verbesserte Auflage.

By Richard Korberr. *Süddeutsche Monatshefte, München.* 1.50 marks. 9½ x 6½; 48; 1935 (paper).

A third revised edition of a bit of propaganda which has apparently had a wide circulation in Germany, in which the author warns of the evils consequent to a declining birth-rate by citing examples from ancient civilizations and many countries of the present time. The factors he cites as causing the present decline are various: industrialized civilization, with crowding into cities; inter-racial marriages; high suicide rates; etc. The introduction is by *Reichsführer* Himmler.



ARTS OF WEST AFRICA (*Excluding Music*).

Edited by Michael E. Sadler. *Oxford University Press, New York.* \$2.00. 9½ x 7½; xi + 98 + 32 plates; 1935.

A short illustrated book for those who are interested in the life of West Africa. The examples have been drawn from the regions between Senegal and Angola. Except for some rather general remarks on the significance and vitality of African art, the book is a series of descriptions of the illustrative plates. There are 32 plates with descriptive notes. There is

also a bibliography of indigenous art in West Africa.



THE BOOK OF A LIFE. *From Generation to Generation.*

By J. C. Connell. *The Ryerson Press, Toronto.* \$2.00. 7½ x 5½; 152; 1935.

The purpose of this book is to provide space to keep a yearly record of one's physical characteristics and development, mental growth, education, attainments, ailments, accidents and general important incidents of life, from birth to death. It is a kind of physical diary, with standard weight, height, and intelligence charts appended, so that anyone can see how he compares with the average.



ZEITSCHRIFT FÜR RASSENKUNDE und ihre Nachbargebiete. 1. Band, 1. 2. 3. Hefte. 2. Band, 1. Heft.

Edited by Egon Freiherr von Eickstedt. *Ferdinand Enke, Stuttgart.* 22 marks per volume of three numbers. 10 x 6½; 112; 1935 (paper).

An excellent new journal covering various aspects of race biology—paleontology, anthropology, ethnology, genetics, eugenics, philology, geography, etc. The articles are published in English, German or French, and the list of collaborators and contributors to these first four numbers is an imposing one. The journal is worthy of a wide circulation among students of human biology, and we wish it all success.



SELECTED REFERENCES IN EDUCATION, 1934. *Supplementary Educational Monographs No. 42.*

By Department of Education, University of Chicago. *University of Chicago, Chicago.* 90 cents. 9½ x 6½; ix + 189; 1935 (paper).

The first issue of this series was noticed in Volume 9, p. 356 of this REVIEW. The reasons for and purpose of the publication were given at that time. The present volume continues the references for 1934. The personnel responsible for this volume is practically the same as that of the earlier one, so that the same accuracy is assured.

ZOOLOGY

THE NATURAL HISTORY OF THE HERRING OF THE SOUTHERN NORTH SEA, being *The Buckland Lectures for 1933.*

By William C. Hodgson. Longmans, Green and Co., New York. \$1.40. 7 x 4½; 120; 1934.

THE HAKE AND THE HAKE FISHERY, Being *the Buckland Lectures for 1934.*

By C. F. Hickling. Edward Arnold and Co., London. 3s. 6d. net. 7 x 4½; 142; 1935.

Francis Trevelyan Buckland, although a surgeon by profession, devoted a large part of his time to the study of animal life, especially of fish and fisheries, and was for some years an Inspector of Fisheries.

He died in 1880, and under his will he left to the nation (Great Britain) a sum of money for the endowment of a Professorship of Economic Fish Culture.

The Buckland Foundation (1926) administers the income derived from the Trust Fund, and under an Order of the Chancery Division of the High Court, dated the 5th July, 1926, three trustees have been appointed to carry into effect a scheme settled by the Court for the application of the bequest. This scheme provides for the appointment annually of a Professor of Economic Fish Culture, to be called the Buckland Professor, whose duty it shall be to deliver lectures at such places, in the United Kingdom or Ireland, as the Trustees shall from time to time determine.

The first book contains three lectures given during the autumn of 1933 at three different towns on the east coast of England. They brought to the members of the herring industry an account of recent researches on the herring and their practical application to the fishing industry. The complete life-cycle of the herring is traced in detail, with descriptions of methods of determining the age and origin of the fish and of predicting the catch.

The second book (lectures for 1934) describes the life history of the hake and the manner in which the habits of the fish affect the yield of the fishery, tells the history of the hake fishery for over a century and what is known about hake population, and discusses the effects of modern fishing methods on the future of the industry.

Both books address themselves to the fishing industry and the general public, and are simply but entertainingly written,

and well illustrated. Neither book has an index.



RAISING REINDEER IN ALASKA. U. S. Department of Agriculture Miscellaneous Publication No. 207.

By Lawrence J. Palmer. U. S. Government Printing Office, Washington. 5 cents. 9½ x 6; 41; 1934 (paper).

To replenish the Eskimo larder and establish a productive industry for Alaska, there were introduced into this northern region from Siberia, between the years 1891 and 1902, 1,280 reindeer. From this number have developed the present herds of approximately a million animals, and reindeer raising is now an established industry engaged in by Eskimos and whites. In 1920 the United States Bureau of Biological Survey began a scientific investigation of the production, and in 1928 was established the Reindeer Experiment Station at College, Alaska. Later two substations were set up, one at Home and another on an island in Bering Sea.

The animals are grazed on open ranges. Each herd, of about 7,000 reindeer on the average, is confined to an individual area, comprising a natural topographic unit. Each unit contains summer and winter ranges, fawning grounds, together with buildings and corrals. The reindeer are herded in much the same manner as cattle on large Western ranges except that the herders, mostly Eskimos and Lapps, follow the animals on foot and are aided by dogs. The animals are rounded up each summer to be marked and counted, and again in the fall or early winter to be butchered. Roundups may also take place in the late summer and in January or February for castrating certain of the bucks to produce steers for meat, and to reduce the number of males to a proper portion of the herd. Some cross-breeding with large selected caribou has been undertaken, resulting in heavier meat producers, better breeders, and more rugged and vigorous animals, better able to shift for themselves. The exports of meat, hides and antlers have steadily increased, and a more recent development

is the "shipping of trained reindeer to the United States each year for display purposes at Christmas time."

The pamphlet presents the latest developments in the studies being made in range and herd management, breeding, feeding, etc., and furnishes directions for carrying out the improved practises.



THE VAMPIRE BAT. *A Presentation of Undescribed Habits and Review of its History.* *Zoologica*, Vol. 19, No. 2.

By Raymond L. Ditmars and Arthur M. Greenhall. New York Zoological Society, New York. 30 cents. 9½ x 6¼; 24; 1935 (paper).

In recent years the vampire bat, *Desmodus rotundus*, has been under suspicion as harboring disease organisms in its saliva. Its guilt was confirmed by the work of Drs. Herbert C. Clark and Lawrence H. Dunn of the Gorgas Memorial Laboratory in Panama, who found it to be a vector of the equine disease "murrina," fatal to horses and mules. The authors made trips to Panama and Trinidad in 1933 and 1934, carried out intensive studies in the field, and brought back specimens for further observations. In addition they have made a thorough search of the literature and thus produced a quite complete history of the vampire.

Beginning with the earliest descriptions the vampire was alleged to be a blood-sucking bat. While Darwin was the first to observe the vampire in the act of drawing blood his observations did not change this belief. It was not until 1932 that Dunn reported: "The vampire does not suck blood, as popularly believed, but takes it up with its tongue, seldom placing its mouth on the wound except when the latter is first made or when the bleeding is very slow. If the wound bleeds freely, the bat simply laps up the blood, hardly touching the tissues, while if the bleeding is scant the bat licks the wounds." With the aid of a moving picture camera Doctor Ditmars and his assistant were able to confirm this observation, and in addition to record the peculiar walking gait of the bat and its manner of stalking its prey. There are seven photographic illustrations and a bibliography of four pages.

THE DISTRIBUTION OF CERTAIN WHALES AS SHOWN BY LOGBOOK RECORDS OF AMERICAN WHALESHIPS. *Zoologica*, Vol. 19, No. 1.

By Charles H. Townsend. New York Zoological Society, New York. \$1.00. 9½ x 6¼; 50 + 4 folding maps; 1935 (paper).

From logbooks of old time whaling vessels in libraries of New England ports celebrated in the history of the whaling industry, and from privately owned logbooks, Dr. Townsend, the Director of the New York Aquarium, has compiled records of whale catches of 744 vessels (1,665 voyages). In the 22 pages of tables are given the name of the whaleship, arranged alphabetically; the date of the voyage and the catch of each voyage by species. On four large folding maps he has platted by latitude and longitude and month, the positions where the 53,877 sperm, bowhead, northern right, southern right, humpback and California gray whales were taken, the positions and extent of the whaling grounds and the seasons when they were visited during the nineteenth century, thus presenting interesting and valuable data regarding the seasonal distribution of whales and their migrations.



APPLIED ENTOMOLOGY. *An Introductory Text-Book of Insects in Their Relations to Man.* Third Edition.

By H. T. Fernald. McGraw-Hill Book Co., New York. \$3.00. 9 x 5½; x + 405; 1935.

This standard text on economic entomology has been revised largely by the addition of new material to bring the book up to date. Certain changes in the text have also been made for the purpose of expressing the facts more clearly. The author points out that the last decade has seen great advances in the field of insect control and has tried to emphasize these advances in the present edition. The book is well illustrated but, unfortunately, lacks an extended bibliography.



A MANUAL OF THE COMMON INVERTEBRATE ANIMALS Exclusive of Insects. Thoroughly Revised Edition.

By Henry S. Pratt. P. Blakiston's Son and Co., Philadelphia. \$7.50. 9 x 6; xviii + 854; 1935.

Pratt's *Manual* is too well known to American biologists to need formal introduction. It has been our standard general taxonomic handbook for a number of years. The present edition, revised largely by systemic experts, has corrected errors which appeared in the first edition, has added new and more representative forms, has stressed the Pacific Coast fauna to a greater degree, and has added a waterproof cover (which will be welcomed by field zoölogists who invariably drop their *Manual* into a lusty stream as they struggle with the identity of some form!) A useful book.



FRIENDLY ANIMALS. *A Book of Unusual Pets. Leisure League Little Book Number 20.*

By Lucile Q. Mann. Illustrations by Benson B. Moore. Leisure League of America, New York. 25 cents. 8 x 5½; 95; 1935 (paper).

This recent addition to the Leisure League Series, by the wife of the Director of the National Zoological Park, is a grand little book—so seductive, in fact, that it will be prudent not to let it fall into the hands of youngsters with a weakness for pets, if you happen to belong to the too large fraction of human beings with an aversion to queer creatures that do not understand about what Mrs. Mann quaintly calls "beautiful manners."

The book starts with the assertion that there is "scarcely an animal in the world that has not at some time been tamed and regarded with affection by its owner," and then goes on to prove, by an amazing array of examples, that this is true. It is extremely well written, coupling real literary charm with sound biology and reliable practical advice about how to make and keep pets. The line drawings that illustrate it are excellent, and have generally an appealing sort of perky quality.

Twenty-five cents cannot be better spent than on this treatise!



A GUIDE TO BIRD SONGS. *Descriptions and Diagrams of the Songs and Singing*

Habits of the Land Birds of Northeastern United States.

By Aretas A. Saunders. D. Appleton-Century Co., New York. \$2.50. 7 x 4½; xvii + 285; 1935.

A unique book. The author has devised a method of recording graphically the songs of birds. By means of this and his descriptions of songs and singing habits it is possible for one to recognize to what species the song belongs without catching a glimpse of the bird. The volume, which is confined to the birds of northeastern United States, does not contain a single bird illustration. After a brief description of each species and its habits there is given a detailed account of the song with an accompanying diagram. Bird lovers will find this a fascinating and highly useful volume. It contains a key to bird songs and is indexed.



LAC AND THE INDIAN LAC RESEARCH INSTITUTE.

By Dorothy Norris, P. M. Glover and R. W. Aldis. Indian Lac Research Institute, Namkum, Ranchi, Bihar, India. Rs. 2/8. 9½ x 7½; iii + 53 + 12 plates; 1934.

The person who buys a can of shellac to varnish a floor is usually ignorant of the source of lac. Lac is produced in India from the resinous secretion of the lac insect, *Laccifer lacca* Kerr, a member of the Coccidae. Besides its use in the paint and varnish industry it is employed in the making of phonograph records, sealing wax, and moulded articles, as an insulating varnish in the electrical industry, and for other purposes. With the development of bakelite and other synthetic resins the Indian government, fearing that the lac industry might go the way of indigo, established a research institute to investigate improved methods of cultivation and manufacture and the development of new uses for lac. The work has included the testing of different species of host trees, their manuring and pruning, investigation of the life history of the lac insect, and control of insect enemies of it and its host trees. A list of Institute publications comprising 89 titles is given.

A PLAN FOR THE MANAGEMENT OF BROWN BEAR IN RELATION TO OTHER RESOURCES ON ADMIRALTY ISLAND, ALASKA. U. S. Department of Agriculture Miscellaneous Publication No. 195.

By B. F. Heintzleman and H. W. Terhune.
U. S. Government Printing Office, Washington. 5 cents. 9½ x 5½; 20; 1934 (paper).

The management of bears of Admiralty Island in Tongass National Forest under the plan set forth in this pamphlet is a coöperative project between the Alaska regional office of the Forest Service and the Alaska Game Commission, both functioning under the Department of Agriculture. It aims to coördinate the management of the bears with timber management activities in connection with the prospective pulp and paper-making development in southeastern Alaska. The essential details of the plan are: To maintain the present bear population of the island by limiting the kill to not exceeding the yearly increase, by seasonal closings of parts of the island to bear hunting and establishing semi-permanent closed areas; to regulate the location of trails, portages, cabins, logging camps and hunting lodges; and to establish a launch patrol around the island during the active salmon spawning period when the bears are congregated at the salmon streams.



BIRD PORTRAITS IN COLOR. Two Hundred Ninety-Five North American Species.

Text by Thomas S. Roberts; Illustrations by Allan Brooks, George M. Sutton, Walter A. Weber, Francis L. Jaques, Walter J. Breckenridge and Louis Agassiz Fuertes. University of Minnesota Press, Minneapolis. \$3.50. 11 x 8½; vi + 90 plates and 90 pages description of plates + 14 pages index; 1934.

This is essentially a reprint of the plates which illustrated *The Birds of Minnesota* with new descriptive text. The descriptions have been made general in application so that they may serve anywhere within the range of the species. Most of the birds of the northern United States and Canada east of the Rocky Mountains are included. A brief description of each

bird depicted is given, including its size and distinguishing marks, its range, its most interesting habits, the type and location of its nest and the color of its eggs. The index includes the popular names in common use in various parts of the country as well as the official and scientific names.



THE HAWKS OF NORTH AMERICA. Their Field Identification and Feeding Habits.

By John B. May. National Association of Audubon Societies, New York. \$1.25. 9½ x 7½; xxxiv + 140; 1935.

This book has been issued as part of an intensive educational campaign by the Audubon societies in behalf of the hawk. The author, widely known as an economic ornithologist, has produced an exceedingly attractive volume. The content is limited to means of identification of the various species (in this the excellent illustrations will be found most useful) and to their food habits. Maps are included showing the geographical occurrence of the species, and in some cases both present and former breeding ranges and wintering areas are shown. There is an appendix on State laws relating to hawks and a lengthy reference bibliography is given but the volume is not indexed.



A SECOND LIST OF ANTILLEAN REPTILES AND AMPHIBIANS. *Zoologica. Scientific Contributions of the New York Zoological Society, Vol. 19, Number 3.*

By Thomas Barbour. New York Zoological Society, The Zoological Park, N. Y. 50 cents. 9½ x 6½; 64; 1935 (paper).

In December, 1930, Barbour published a list of the Antillean reptiles and amphibians in *Zoologica*. Since that time so many additional discoveries have been made that the first list is out of date. The large number of requests for the list having indicated its usefulness the author has prepared a second list of the reptiles and amphibians of the Antilles. The Antilles considered faunistically comprise the West Indian Islands, except Trinidad, Tobago and the islands off the coast of South and Central America.

THE REPTILES OF CHINA. *Turtles, Crocodilians, Snakes, Lizards. Natural History of Central Asia, Volume 10.*

By Clifford H. Pope. American Museum of Natural History, New York. \$10.00. 11 x 8½; lli + 604 + 27 plates and folding table; 1935.

This book reports studies of Chinese reptiles made by field workers of the American Museum of Natural History. The turtles, snakes, crocodiles, and lizards are all treated in detail. The material is largely taxonomic in nature, the forms being considered species by species. The annotations for each species include such data as the taxonomic history of the form; a morphological description; notes on habits and habitats; source of the material examined, and specific remarks. Taxonomic keys, as well as illustrations, serve to facilitate determinations. An important contribution to the herpetology of the world.



ONCHOCERCIASIS with Special Reference to the Central American Form of the Disease. *Contributions from the Department of Tropical Medicine and the Institute for Tropical Biology and Medicine, No. 6.*

By Richard P. Strong, Jack H. Sandground, Joseph C. Bequaert and Miguel M. Ochoa. Harvard University Press, Cambridge. \$4.00 (paper); \$5.00 (cloth). 10½ x 7½; xiv + 234 + 6 plates + map; 1934.

In the African and Central American tropics there is a disease known as onchocerciasis which is caused by a filarian worm, *Onchocerca caecutiens*. Little of an exact nature has been known about the clinical and biological aspects of this malady until the present report, which summarizes much material on the pathology, etiology, epidemiology and general biology of the disease. The authors show that this nematode is associated with the production of subcutaneous tumors, as well as other pathological lesions, in the head and thorax region. The worms are transmitted by the fly, *Simulium*. This is an important contribution to medical helminthology.

THE EUROPEAN CORN BORER AND ITS CONTROLLING FACTORS IN THE ORIENT. *U. S. Department of Agriculture Technical Bulletin No. 455.*

By Charles A. Clark. U. S. Government Printing Office, Washington. 5 cents. 9½ x 6; 38; 1934 (paper).

This bulletin is based on the results of an investigation of the European corn borer and its parasites in Japan, Manchuria, Chosen and Taiwan. It was found that no one parasite attacked *P. nubilalis*, and therefore the authors recommend that the proper policy with regard to "parasite introduction against *Pyrausta nubilalis*, was to collect and ship all the primary parasite species obtainable without regard to the stage of the host which they attacked." More intensive investigations of the problem are needed.



THE ANIMAL WORLD. *Animal Life of Our Earth.*

By James G. Needham. The University Society, New York. 65 cents (paper); \$1.00 (cloth); (prices slightly higher on West Coast). [Accompanying "Explanatory Reading Outline" 5 cents]. 9 x 6; vi + 116; 1931.

The author traces the history of man's domestication and use of animals from remote times to the present. The last chapters are devoted to a discussion of many different subjects, such as metamorphosis, migrations, methods of defense of animals, hibernation, animal societies and castes, and finally the "world of infinitely small things" as revealed by the microscope. Although such a wide variety of subjects is covered there is little confusion and the book serves as an excellent orientation to the animal world.



THE WATERFOWL FLYWAYS OF NORTH AMERICA. *U. S. Department of Agriculture Circular No. 342.*

By Frederick C. Lincoln. U. S. Government Printing Office, Washington. 5 cents. 9½ x 6; 12; 1935 (paper).

There are four distinct flyways followed in the spring and fall migrations of the waterfowl. The terms given to them

are Atlantic, Mississippi, Central and Pacific. The most rapid decrease in recent years has been in the Central and Pacific Coast areas, resulting from drought, agricultural activities and overshooting. The decrease has been so rapid that a complete suspension of shooting privileges for a time may become necessary on all of the flyways.



BIRDS IN BRITAIN TO-DAY.

By Geoffrey C. S. Ingram and H. Morrey Salmon. Ivor Nicholson and Watson, London. 12s. 6d. net. $9\frac{1}{2} \times 7\frac{1}{2}$; x + 145 + 51 plates; 1934.

This book is an interesting natural history study of British birds based upon the personal experiences and bibliographic researches of the authors. The volume takes up the birds taxonomically and gives descriptive data about the forms themselves and their habits and habitats. There are some 66 excellent illustrations supplementing the text.



DROSOPHILA MELANOGASTER MEIG. *Eine Einführung in den Bau und die Entwicklung.*

By Eduard H. Strasburger. Julius Springer, Berlin. 6.90 marks. $9\frac{1}{2} \times 6\frac{1}{2}$; iv + 60; 1935 (paper).

This introduction to the anatomy and development of *Drosophila melanogaster* contains six sections. Section I deals with feeding, raising, general care, and different histological techniques to be used. Section II discusses larvae from histological and anatomical aspects; Section III, pupae; Section IV, imagoes; Section V, the embryological development; Section VI, bibliography. The book is intended as a general laboratory guide.



LEÇONS DE ZOOLOGIE. *Annelides. Actualités Scientifiques et Industrielles* 196.

By M. Prenant. Hermann et Cie, Paris. 16 francs. $10 \times 6\frac{1}{2}$; 95; 1935 (paper).

In this book the general biology of the phylum Annelida is reviewed in a conventional way by discussing the type-forms *Polygordius*, *Nereis*, *Lumbricus* and

Hirudo briefly and somewhat inadequately. The reviewer was not greatly impressed by the book. It is interesting to note that the echiurid worms are placed with the annelids.



LEÇONS DE ZOOLOGIE ET BIOLOGIE GÉNÉRALE. VII. *Vertébrés Supérieurs (Oiseaux et Mammifères)*. *Actualités Scientifiques et Industrielles*, 207.

By Georges Bohn. Hermann et Cie, Paris. 18 francs. $10 \times 6\frac{1}{2}$; 131; 1935 (paper).

This is the seventh in a series of outlines of zoology and general biology. It treats of the embryology, anatomy and physiology of birds and mammals. The descriptions are schematic but from them the student should be able to learn the essentials and the method of approach to a more complete study of the subject. Included is also a well written summary of Lamarck's and Darwin's theories of evolution.



A REVISIONAL STUDY OF THE GENUS *SCOLYTUS* GEOFFROY (*ECCOPTOGASTER* HERBST) IN NORTH AMERICA. U. S. Department of Agriculture Technical Bulletin No. 431.

By M. W. Blackman. U. S. Government Printing Office, Washington. 5 cents. $9\frac{1}{2} \times 6$; 31; 1934 (paper).

This bulletin attempts to clear up the uncertainty which has existed in the past about the identity of several of Leconte's species of *Scolytus*. By far the major portion of the bulletin is devoted to descriptions of the North American species. Twenty-three different species are discussed in detail.



DEVELOPMENT OF THE SWINE NEMATODE *STRONGYLOIDES RANSOMI* AND THE BEHAVIOR OF ITS INFECTIVE LARVAE. U. S. Department of Agriculture Technical Bulletin No. 437.

By John T. Lucker. U. S. Government Printing Office, Washington. 5 cents. $9 \times 5\frac{1}{2}$; 30; 1934 (paper).

It is shown in this pamphlet that the

infective larvae of the swine nematode *Strongyloides ransomi* enter their host either through the skin or else through the mouth. Certain control measures for killing the larvae are recommended.



THE REPRODUCTIVE HABITS OF THE COMMON CATFISH, *AMEIURUS NEBULOSUS* (LE SUEUR), WITH A DISCUSSION OF THEIR SIGNIFICANCE IN ONTOGENY AND PHYLOGENY. *Zoologica, Volume 19, Number 4.*

By C. M. Breder, Jr. New York Zoological Society, The Zoological Park, New York. 35 cents. 9½ x 6½; 42; 1935 (paper).

MAMMALS COLLECTED BY T. T. AND E. B. MCCABE IN THE BOWRON LAKE REGION OF BRITISH COLUMBIA. *University of California Publications in Zoology, Volume 40, Number 9.*

By E. Raymond Hall. University of California Press, Berkeley. 25 cents. 10¼ x 6½; 24; 1934 (paper).

GEOGRAPHIC DISTRIBUTION OF POCKET GOPHERS (GENUS *THOMOMYS*) IN NEVADA. *University of California Publications in Zoology, Volume 40, Number 10.*

By E. Raymond Hall and William B. Davis. University of California Press, Berkeley. 25 cents. 10¼ x 6½; 16; 1935 (paper).

CILIATES FROM *BOS GAURUS* H. SMITH. *University of California Publications in Zoology, Volume 39, Number 17.*

By C. A. Kofoed and John F. Christenson. University of California Press, Berkeley. 75 cents. 10¼ x 6½; 52 + 5 plates; 1934 (paper).

A COMPARISON OF THE DISTRIBUTION OF THE INTESTINAL PROTOZOA OF THE NORWAY RAT, WOOD RAT, AND GUINEA PIG, WITH REFERENCE TO THE HYDROGEN ION CONCENTRATIONS AS DETERMINED BY THE GLASS ELECTRODE. *University of California Publications in Zoology, Volume 41, No. 1.*

By C. A. Kofoed, E. McNeil, and A. E. Bonestell. University of California Press, Berkeley. 25 cents. 10¼ x 6½; 8; 1935 (paper).

THE CYCLE OF *TRYPANOSOMA CRUZI* IN TISSUE CULTURE OF EMBRYONIC HEART MUSCLE. *University of California Publications in Zoology, Volume 41, Number 3.*

By C. A. Kofoed, F. D. Wood, and E.

McNeil. University of California Press, Berkeley. 25 cents. 10¼ x 6½; 2; 1935 (paper).



BOTANY

A TEXTBOOK OF GENERAL BOTANY. *Third Edition.*

By Gilbert M. Smith, James B. Overton, Edward M. Gilbert, Rollin H. Denniston, George S. Bryan and Charles E. Allen. The Macmillan Co., New York. \$3.50. 8½ x 5½; x + 574 + 4 plates; 1935.

A LABORATORY MANUAL OF GENERAL BOTANY. *Revised Edition.*

By Emma L. Fisk and Ruth M. Addoms. The Macmillan Co., New York. \$1.00. 8½ x 5½; x + 137; 1935.

As textbook revisions go, this standard college textbook has been subjected to drastic changes since the appearance of the second edition seven years ago. New chapters have been added and others have been shifted about to create a more logical sequence of topics; the results of recent research have been incorporated; and the text has been rewritten generally. The quality of the illustrations has been improved by redrawing some, enlarging many, and by a general improvement in the reproduction of both drawings and photographs. Many substitutions have been made to good advantage. The last three-fifths of the book, dealing with the various divisions of the plant kingdom, have been somewhat less changed than the rest, but here, too, improvement is evident. It is a first-rate textbook. There is an excellent index.

This excellent laboratory manual was written to accompany the foregoing *Textbook of General Botany*, though of course it has other uses. "The manual as it stands is suitable for use in a year course involving four or five hours laboratory work per week." Care has been exercised that the student should understand the significance of the observations he is called upon to make and the directions are reasonably complete. An appendix contains valuable notes for the laboratory instructor on the sources of material, and the formulae for reagents and culture solutions are clearly given.

PRIMITIVE LAND PLANTS *also known as The Archegoniatae.*

By F. O. Bower. *The Macmillan Co., New York.* \$8.00. 8 $\frac{1}{2}$ x 5 $\frac{1}{2}$; xiv + 658; 1935. In summary, Bower says:

The chief object of this work has not been to trace phyletic relations between Archegoniate Plants; though those who will may be interested to use the data here supplied in that way. It has rather been by examining them comparatively, to visualise the Methods of Advance which these primitive Land-Plants appear to have followed in their evolution. The primary source of evidence has been the study of the living Archegoniatae; but the reasoning based on these has been checked by reference to palaeontological facts. This mode of enquiry should lead to more valuable results in the organographic study of Land-Plants at large than any mere search for phyletic schemes.

The fundamental nature of this work does not need to be pointed out to students of plant morphology. It represents a continuation of the line of work that led to the publication of *The Origin of a Land Flora* in 1908 rather than a revision of that book. The important literature citations are listed in each chapter and there is a good index.



RESPONSES OF STRAWBERRY VARIETIES AND SPECIES TO DURATION OF THE DAILY LIGHT PERIOD. *U. S. Department of Agriculture Technical Bulletin No. 453.*

By George M. Darrow and George F. Waldo. *U. S. Government Printing Office, Washington.* 5 cents. 9 x 5 $\frac{1}{2}$; 31; 1934 (paper). The studies described in this bulletin were conducted to ascertain the influence of light upon the regional adaptation of different varieties of strawberries. Among the conclusions reached are:

Southern varieties grow under short days at relatively low-growing temperatures and need little rest or no dormant period.

Northern varieties grow very little under short days and, if first exposed to short daily light periods, require a low-temperature dormant period to break their rest period.

The response of varieties to light conditions during October, November, and December is considered indicative of their regional adaptation. Varieties adapted to southern States produce relatively large leaves with long petioles, while northern varieties grow little or not at all during these months.

INFLUENCE OF SPACING AND TIME OF PLANTING ON THE YIELD AND SIZE OF THE PORTO RICO SWEETPOTATO. *U. S. Department of Agriculture Circular No. 327.*

By J. H. Beattie, Victor R. Boswell and E. E. Hall. *U. S. Government Printing Office, Washington.* 5 cents. 9 x 5 $\frac{1}{2}$; 10; 1934 (paper).

Results of experiments conducted with the Porto Rico sweet potato at the Pee Dee Experiment Station at Florence, S. C., include:

Spacings of 6, 9, 12, and 15 inches between plants of the Porto Rico sweetpotato in 4-foot rows showed that the closer spacings decreased the proportion and yield of jumbo size roots and that the 6-inch spacing increased the proportion and yield of No. 2 sweetpotatoes over the 9, 12, and 15-inch spacings. These spacings did not appreciably affect the proportion or yield of No. 1 or the total yield.

There was a consistent decrease in yield of No. 1 sweetpotatoes as the planting date was delayed.

These investigations have shown that closer spacing is better than delayed planting to reduce the proportion of jumbos, since closer spacing within proper limits does not reduce yields of marketable roots or the total yield.



AN INTRODUCTION TO PLANT LIFE.

By Carl L. Wilson and Julia M. Haber. *Henry Holt and Co., New York.* \$3.00. 8 $\frac{1}{2}$ x 5 $\frac{1}{2}$; xiv + 493; 1935.

This textbook is intended for colleges offering half-year courses in botany for students who are not expected to continue biological work. Accordingly, the subject matter is for the most part limited to the topics that make the readiest appeal to the interest of students, the structure and properties of economic plants, the relation of plants to man, and the similarities and differences of plant and animal structure and function. The discussions of life histories have been greatly abbreviated, compared with other texts, and in general the kind of botanical knowledge that is based on microscopical observation is presented very briefly. There are a large number of illustrations, most of them photographs; bibliographies of reference books follow each chapter, and there is a good index.

GYMNOSPERMS. *Structure and Evolution.*

By Charles J. Chamberlain. *University of Chicago Press, Chicago.* \$4.50. 9 x 6; xi + 484; 1935.

This is a revision of Coulter and Chamberlain's *Morphology of the Gymnosperms*, a standard textbook for graduate students of botany. A large number of illustrations, chiefly photographs of gymnosperms in their native habitat, have been added, making it a profusely illustrated volume. The text has been brought up to date, particularly in respect to histological, cytological, and paleontological details. New chapters have been added showing the relation of the gymnosperms to the rest of the plant kingdom and discussing their paleontological history. There is a good index and a bibliography of more than 700 titles.

**BOTANY. *Principles and Problems. Third Edition.***

By Edmund W. Sinnott. *McGraw-Hill Book Co., New York.* \$3.50. 9 x 5½; xix + 525; 1935.

Two characteristic features of Sinnott's textbook are the large proportion of diagrammatic drawings and the "Questions for Thought and Discussion" (782 in all) following each chapter. The third edition has benefited by a thorough revision; a more modern system of phylogeny and classification of the vascular plants has been used, and a chapter on experimental morphology has been added. The "Reference Problems" have finally been omitted, a wise move, especially since there are no bibliographies to assist a student in the profitable use of his time in trying to answer these questions. The quality of the illustrations has been considerably improved. There is a good index.

**A TEXT-BOOK OF MYCOLOGY.**

By Ernst A. Bessey. *P. Blakiston's Son and Co., Philadelphia.* \$4.00. 8½ x 5½; xv + 495; 1935.

This textbook is admirably adapted to the needs of second-year botany students. It

is intended to provide "an idea of the structure, life history and classification of the more important groups of parasitic fungi." It is not limited to these groups, however, for Bessey's interest in systematic relationships is too strong, and accordingly the Mycetozoa and Plasmodiophorales are included too. It is thoroughly up to date. There is an excellent index and the section entitled "Guide to literature for identification of fungi" has an annotated bibliography covering 73 printed pages. We predict that a great many mycologists will be grateful for this feature.

**HISTOLOGICAL CHARACTERS OF FLAX ROOTS IN RELATION TO RESISTANCE TO WILT AND ROOT ROT. *U. S. Department of Agriculture Technical Bulletin No. 458.***

By Lytton W. Boyle. *U. S. Government Printing Office, Washington.* 5 cents. 9½ x 6; 19; 1934 (paper).

Three types of flax were selected for this study, according to their reaction to root diseases. These types were respectively resistant, partially resistant, and susceptible. Differences in these three groups were found in the stability of the cortical cell walls of the roots. The most important result was that "(1) two types of diseases, namely wilt and root rot, may occur when flax is grown in soil that has produced this crop at frequent intervals for many years, and (2) that resistance to each of these two types of disease is due to distinctly different characters of the flax plants."

**THE SOYA BEAN. *Its History, Cultivation and Uses.***

By Elizabeth Bowdidge. *Oxford University Press, New York.* \$2.00. 7½ x 5; x + 82; 1934.

This little book has been prepared to interest the British farmer in the cultivation and many uses of the soya bean. Experiments in England are in the initial stage but indications are that high protein-yielding varieties can be successfully grown. The writer has drawn largely on

the results of investigations carried on in the United States and Canada but she also includes all important data at present available on experimental work in England. Numerous tables are given in the text but there is neither a bibliography nor an index included in the survey. Sir John T. Davies contributes a foreword.



THE TRANSLOCATION OF SOLUTES IN PLANTS.
A Critical Consideration of Evidence Bearing upon Solute Movement.

By Otis F. Curtis. McGraw-Hill Book Co., New York. \$3.00. 9 x 6; xiii + 273; 1935.

This volume is a valuable addition to the little list of monographs on special topics of plant physiology. Curtis has been an active student of the phenomenon of translocation of nutrient materials in plant tissue for many years and so it is only natural that a considerable portion of the book is devoted to his own work. A valuable feature of the book is the summary that follows each chapter, presenting in brief the principal conclusions that can be drawn from the experiments just discussed. There is an excellent bibliography and an excellent index.



LES CÉRÉALES. *Biologie et Applications.*

By R. Legendre. Armand Colin, Paris. 10.50 francs (paper); 12 francs (cloth). 6½ x 4½; 218; 1935.

Legendre's treatise was written for agricultural experiment station workers and for engineers in charge of the storage of grain. The first half of the book is a consideration of the physiology of the wheat grain. The treatment, though sound, is far from being novel. The last half of the book deals with economic considerations, production statistics, and the principles involved in grain storage. The book has been well assembled from the older, standard sources by dint of patient hack work, but there is not much to recommend it to American agricultural workers.

MANAGEMENT OF AMERICAN FORESTS.

By Donald M. Matthews. McGraw-Hill Book Co., New York. \$5.00. 9 x 6; xv + 495; 1935.

A thorough and sound exposition of the economic and financial aspect of forest management. The first part deals with the estimation of yields in relation to site and stocking of growth, the different methods of silviculture, their relative advantages and theoretical expectations under specific conditions. In the second part of the book the problems of capitalization and valuation of forests and production are examined in detail. The author has emphasized throughout the commercial objective of forest management so that this book has both theoretical and practical value.



WACHSTUMSBEEINFLUSSUNG UND LEISTUNGSREGELUNG BEI EINER EINZELLIGEN PFLANZE.

By Max Hahn. Sommer und Schorr, Feuchtwangen. 2.50 marks. 8½ x 5½; 75; 1935 (paper).

Hahn reports experiments on the growth and chemical physiology of *Torula rufa*, a new, pigmented species, which he describes. He was mainly concerned with the influence of filter paper on growth and with the influence of mineral salts. Boron and vanadium stimulated growth, and he notes the effects of several other salts besides the ones usually used for nutrition. There is a bibliography and a table of contents.



THE PLANT WORLD. *Plant Life of Our Earth.*

By C. Stuart Gager. The University Society, New York. 65 cents (paper); \$1.00 (cloth); (prices slightly higher on West Coast). [Accompanying "explanatory Reading Outline," 5 cents.] 9 x 6; viii + 136; 1933.

This summary of some of the most interesting phenomena in the plant world is clearly and entertainingly written. The author, after giving a brief account of theories of plant origin, discusses: Clas-

sification, life activities of plants, symbiosis, respiration, photosynthesis, color, pollination, plants and insects, seed dispersal, variation, Darwinism and evolution.



A METHOD FOR DETERMINING THE NUTRIENT NEEDS OF SHADE TREES WITH SPECIAL REFERENCE TO PHOSPHORUS. *Black Rock Forest Papers, Vol. 1, No. 1.*

By Harold L. Mitchell. *Black Rock Forest, Cornwall-on-the-Hudson, New York.* 11 x 8½; 4; 1935 (paper).



MORPHOLOGY

THE BRAIN Considered Anatomically, Physiologically and Philosophically. Vol. I. The Cerebrum and Its Parts. Vol. II. The Pituitary Gland, The Cerebellum and the Medulla Oblongata.

By Emanuel Swedenborg. Edited, Translated, and Annotated by R. L. Tafel. Swedenborg Society, London. 15 shillings per volume. 8½ x 5½; Vol I, xxxviii + 794; Vol. 2, xvi + 645; 1934.

The Swedenborg Society deserves great credit for reprinting this scholarly work which was first compiled and published in 1882-1887. It includes a translation of Swedenborg's manuscript treatise on the brain, written between 1741 and 1744, and relevant material from his *Oeconomia Regni Animalis*, published in 1740 and 1741, and *Regnum Animale*, published in 1744 and 1745, plus commentaries and quotations from the work of other observers prior to 1877 who corroborated the observations and theories set forth by Swedenborg. It should be of interest to medical historians.



DIRECTIONS FOR THE DISSECTION OF THE CAT. *Revised Edition.*

By Robert P. Bigelow. *The Macmillan Co., New York.* 90 cents. 7½ x 5; xi + 65; 1935.

A small laboratory handbook covering the various systems and organs of the cat with instructions for their dissection. The stu-

dent is not "told all" in the text; some of the facts he must either deduce or find out by collateral reading. Frequent literature citations appear in the text to aid in this reading.



VARIATIONS IN THE CYTOLOGY OF THE BLOOD OF GECKOS (*TARENTOLA MAURITANICA*) INFECTED WITH *HAEMOGREGARINA PLATYDACTYLI*, *TRYPANOSOMA PLATYDACTYLI*, AND *PIRHEMOCYTON TARENTOLAE*. *University of California Publications in Zoology, Volume 41, Number 2.*

By Sherwin F. Wood. *University of California Press, Berkeley.* 25 cents. 10½ x 6½; 13 + 2 plates; 1935 (paper).

UNIPOLAR INGRESSION IN *TRITURUS TOROSUS*: A Hitherto Undescribed Movement in the Pregastrular Stages of a Urodele. *University of California Publications in Zoology, Volume 39, Number 15.*

By A. Mandel Schechtman. *University of California Press, Berkeley.* 25 cents. 10½ x 6½; 6 + 1 plate; 1934 (paper).

THE DETERMINATION OF THE MEDULLARY PLATE IN *TRITURUS TOROSUS* (RATHKE). *University of California Publications in Zoology, Volume 39, Number 18.*

By A. Mandel Schechtman. *University of California Press, Berkeley.* 25 cents. 10½ x 6½; 16 + 1 plate; 1935 (paper).



PHYSIOLOGY AND PATHOLOGY

A BIBLIOGRAPHY OF THE POEM *SYPHILIS SIVE MORBUS GALLICUS* by Girolamo Fracastoro of Verona.

By Leona Baumgartner and John F. Fulton. *Yale University Press, New Haven.* \$5.00. 9½ x 6½; 157; 1935 (paper).

In 1493 an epidemic broke out among the troops of Charles VIII of France, then at Naples. Whether it was a new disease, brought back from America by the sailors of Columbus, or an epidemic and virulent form of a disease already present in Europe is still a matter for dispute among medical historians. The epidemic, known at first as the Neapolitan or the French disease, "spread throughout Italy, and in a few years Europe was aflame." In 1530 Fracastoro, an Italian humanist and physician,

published a poem in Latin, *Syphilis sive Morbus Gallicus*, from whose hero, Syphilus, a shepherd whose impiety provokes Apollo to punish him with the disease, the latter was given the name which it now bears. Moreover in this poem, as well as in his later prose treatise *De Contagione*, Fracastoro suggested that the cause of contagious diseases was certain *semina*, capable of self-multiplication, which passed from the infector to the infected. The likeness of this to the modern germ theory of disease led Sudhoff to hail Fracastoro as "the father of modern epidemiology."

Fracastoro's poem has not shared the oblivion which has overwhelmed most of the Latin poetry of the Renaissance. In this scholarly bibliography no fewer than one hundred Latin editions and translations into Italian, English, French, German, Spanish and Portuguese are recorded besides 106 titles of biography and criticism. It is amusing to note that Nahum Tate, whose translation of the Psalms into English verse still holds a place in our hymnals, also made the first complete translation of *Syphilis* into any language. The bibliography also contains an eloquent introduction by Dr. Arnold C. Klebs, a photograph of a bust by Danese Cataneo believed by Ilg and Klebs to represent Fracastoro, reproductions of title-pages, and an adequate index.



PACEMAKERS IN RELATION TO ASPECTS OF BEHAVIOR.

By Hudson Hoagland. *The Macmillan Co., New York.* \$3.00. 8½ x 5½; x + 138; 1935.

The Experimental Biology Monographs, of which this is the first volume, "will be biological essays by active workers in the field, in which experimental contributions are synthesized and hypotheses proposed which may stimulate further research. They will not only present factual summaries of recent advances in research work but will also show the broad bases and theoretical implications of such advances."

In this interesting monograph Professor Hoagland makes the acute observation

that most behaviorists, in spite of their pretensions to objectivity, know too little of physiology to relate effectively their experimental results to specific physiological mechanisms. His aim in this book is "to show how certain principles of general physiology may be useful in investigations of problems of traditional interest to psychologists, but usually interpreted by them in terms devoid of physicochemical meaning." He finds that an important factor in the kinetics of nerve tissue is the ratio of potassium inside the tissue and in its internal environment. He gives reasons for concluding that the adaptation of cutaneous nerve fibers to repetitive stimuli is due to the accumulation around the nerve fiber of potassium released from neighboring epithelial cells by the stimulus. He finds also that the values of μ , the temperature characteristic of the Arrhenius equation, for a wide variety of vital processes are grouped in definite modes and infers that this implies "the existence of a limited number of catalytic substances involved in the control of master reactions determining rates of a wide variety of physiological processes." However, while some of the modes in his Figure 8 are undoubtedly significant, others may well be merely variations of sampling.

A bibliography of eight pages and author and subject indexes are given.



LES MIGRAINES. *Étude Pathogénique, Clinique et Thérapeutique.*

By Pasteur Valléry-Radot and Jean Hamburger, with the collaboration of P. Blamontier. *Masson et Cie, Paris.* 45 francs. 9½ x 6; 231; 1935 (paper).

This is an exhaustive and critical exposition of the symptomatology, pathology, and therapy of migraine. Introduced by a historical summary, the first part contains a detailed description of the order of the symptoms in the more common as well as in the more infrequent forms of this condition. In the second part the authors discuss with extreme clearness the theories and observations on the mechanism and etiological factors presumably involved in the production of migraine. They arrive at the generally accepted conclusion that

while the ophthalmic symptoms may be regarded as due to a cerebral vascular spasm (not necessarily but probably of sympathetic origin), there is no consistent explanation for the headache, vomiting, etc. The authors recognize the importance of the hereditary, humoral and other so-called constitutional factors in favoring the production of this syndrome but emphasize the lack of comprehensive data. They believe migraine may be regarded as due either to endocrine, digestive, hepatic, allergic or neurological disturbances. It is towards these basic pathologic conditions that treatment should be directed. And in the third part they evaluate the different methods of treatment proposed. A fairly complete bibliography at the end of each chapter adds still more to the value of this excellent treatise.



ANESTHÉSIE ET ANALGÉSIE. *Organe Officiel de la Société Française d'Anesthésie et d'Analgésie*, Vol. 1, No. 1.

Editor-in-Chief: Robert Monod, with the assistance of A. Gosset, Léon Binet, E. Desmarest, Émile Forgue, E. Fourneau, Pierre Fredet, A. Haurant, M. Tiffeneau, M. Thalheimer; G. Jacquot, Secretary. Masson et Cie, Paris. 60 francs (France and Colonies); 80 francs (foreign) per volume of 4 numbers. 9½ x 7; 120; 1935 (paper).

In this new journal will be published the results of original research, and critical reviews of the literature in the field of anesthesia and analgesia, realizing in this way a liaison between the inventors (chemists, physiologists and manufacturers) and the users of anesthetics. In the first number appear the following papers: The present state of the question of anesthesia; The sedative and analgesic actions of piperidinomethyl-benzoidioxand (F. 933) and its near derivatives with animals; Rachidian anesthesia by the use of percaine in surgery on the submesocolic region of the abdomen; The extent of anesthesia in the vertebral column in rachianesthesia, Jones's method; Biological modifications produced in the organism by different methods of anesthesia. There is an "Index Bibliographique" of 11 pages in

addition to reviews of thirteen papers published in other journals.



HEALTH and a Changing Civilisation.

By E. Obermer. John Lane, London. 3s. 6d. net. 7½ x 4½; xv + 171; 1935.

What is the relation of the medical scientist to health, in contradistinction to his usual relation to disease, and what can be done about it? This is the problem presented and discussed in the present volume. The author claims that if a real system of preventive medicine is to be developed the layman, as well as the professional, must put his shoulder to the wheel. One way to meet the problem is, of course, through the further extension and perfection of public health services. The other way, which must work along with the former, is the introduction of a competent, open to all, individual health service. Doctor Obermer visualizes here an institute which he calls the Individual Health Centre; an institution whose organization and functions are developed in his book.

This is an interesting book and, although it is not unusually original, yet it does suggest and strive for an important public enterprise.



INDIVIDUAL HEALTH. *A Technique for the Study of Individual Constitution and Its Application to Health. Volume I, Biochemical Technique.*

By E. Obermer and R. Milton. Chapman and Hall, London. 15 shillings net. 8½ x 5½; xvi + 244 + 12 plates and 4 folding tables; 1935.

This work is written for the "physician of the future" whose primary concern will be "to prevent disease by the promotion of health or maximum functional efficiency." This volume is the first of two outlining a proposed technique of a complete "adaptational survey," the objective of which is:

to assess the efficiency with which the subject adapts himself to his particular environment, his particular mode of life, diet, exercise, rest, sleep, etc.

It follows for instance therefore that very little, if any, information can be derived from the almost universal practice of carrying out analyses on 24 hour specimens of urine only. When serial quantitative

analyses of the normal constituents of the urine are made and plotted out on a graph . . . these are capable of mirroring fluctuations in the Acid Base balance and Mineral metabolism of the individual which are of the greatest diagnostic interest.

The present volume is confined to detailed descriptions of biochemical techniques which the authors have worked out for serial analyses of blood, ingesta, urine and faeces. It contains numerous illustrations and inserted charts of record forms and floor plans, a bibliography and an index.



SOME NOTABLE EPIDEMICS.

By H. Harold Scott. *William Wood & Co., Baltimore.* \$4.75. 8½ x 5½; xix + 272; 1934.

The purpose of this "anthology" is to show how the many obscure and puzzling problems of British epidemics of the past have been met by investigation. Beginning with the Broad Street Pump outbreak of cholera in 1854 Dr. Scott has chosen those epidemics of enteric fever, diphtheria, scarlet fever and food-poisoning which are of sufficient historical value to have become classic or which illustrate particular points, such as the first employment of chlorine as a means of disinfecting water-mains, or water supplies, or the use of pasteurization in cutting short a milk borne epidemic, etc. The survey is of importance to the student of medical history in that material that has not been generally available heretofore is now at his disposal. The student of public health will find that a knowledge of the contents of this book, which so clearly emphasizes the importance of an accumulation of evidence from medical, chemical and sociological sources in any investigation of obscure outbreaks, will be of value in his own work. The volume contains a number of tables and graphs and is documented and indexed.



DIE BEHANDLUNG DER ALTEN UND KRANKEN BEI DEN NATURVÖLKERN.

By John Kory. *W. Kohlhammer, Stuttgart.* 13.50 marks (paper). 9½ x 6½; xxxix + 374; 1934 (paper).

The first part of the book is a survey of the

treatment of the aged among primitive peoples and early German, Scandinavian, Slavic, Greek, Oriental, etc. cultures. The second part is a critical discussion of the major theories advanced concerning the origin and development of the custom of eliminating from the tribe the aged, diseased, and crippled, either by exposure and neglect or actual killing. None of these theories—evolutionism, nomadism, the religio-magic theory advanced by Lévy-Bruhl, or Freud's hypothesis—does Kory find comprehensive enough. He himself is inclined to believe that these customs are due to a combination of causes, utilitarian and non-altruistic in character, arising from more complicated methods of obtaining food and a living, enmity between tribes, etc.

The book is a scholarly compilation, well documented, and equipped with a thirty-page bibliography and an index. It is designed for the layman interested in social origins, as well as for the specialist.



THE CARE OF THE AGED, THE DYING AND THE DEAD.

By Alfred Worcester. *Charles C Thomas, Springfield, Ill.* \$1.00. 7½ x 5; vii + 77; 1935 (paper).

In this booklet are reprinted three lectures on the art of medical practice by the Henry K. Oliver Professor of Hygiene at Harvard. In the first, "The Care of the Aged," he gives some sane advice to medical students and young practitioners on the care and treatment of elderly patients. In the second, "The Care of the Dying," he deplores the deterioration of the art of caring for the dying, with the result that there is much less known about it, and admonishes the physician to stand by and give all possible comfort and relief to the patient until the end. The third lecture, "The Care of the Dead," carries the obligations of the physician still further—to aid in the advance of medical science by securing consent for post-mortem examinations; to aid society by breaking down the prejudices against cremation and thus saving the bereaved family from the extortionate prices of the undertakers and avoiding land sequestration for graveyards.

MEDICAL AND SANITARY REPORTS FROM BRITISH COLONIES, PROTECTORATES AND DEPENDENCIES FOR THE YEAR 1930. *Tropical Diseases Bulletin Vol. 29, Supplement.*

Summarized by H. Harold Scott. Bureau of Hygiene and Tropical Diseases, London. 2s. 6d. net. $9\frac{3}{4} \times 6\frac{1}{8}$; 148; 1932 (paper).

MEDICAL AND SANITARY REPORTS FROM BRITISH COLONIES, PROTECTORATES AND DEPENDENCIES FOR THE YEAR 1931. *Tropical Diseases Bulletin Vol. 30, Supplement.*

Summarized by H. Harold Scott. Bureau of Hygiene and Tropical Diseases, London. 5 shillings net. $9\frac{3}{4} \times 6\frac{1}{8}$; 238; 1933 (paper).

MEDICAL AND SANITARY REPORTS FROM BRITISH COLONIES, PROTECTORATES AND DEPENDENCIES FOR THE YEAR 1932. *Tropical Diseases Bulletin Vol. 31, Supplement.*

Summarized by H. Harold Scott. Bureau of Hygiene and Tropical Diseases, London. 5 shillings net. $9\frac{3}{4} \times 6\frac{1}{8}$; 219; 1934 (paper).

These are detailed and useful summaries of the hygienic conditions existing in each of the British Colonies, protectorates and dependencies. Vital statistics, maternity and child welfare, school hygiene, sanitation, water supply, hospital, dispensary and clinical returns and chief diseases treated, are discussed in most instances, and accurate and full data are given.



SYNDROMES MÉTÉOROPATHOLOGIQUES ET INADAPTÉS URBAINS.

By G. Mouriquand and P. Jossierand. Masson et Cie, Paris. 16 francs. $7\frac{1}{4} \times 5\frac{1}{2}$; 126; 1935 (paper).

A summary of some clinical conditions associated with meteorological changes. Besides the well-known effects of heat and cold the authors describe a more complex condition which they name South Wind syndrome and which is also known as the Föhn syndrome. In infants it is characterized by general irritability, headaches, temperature rises and symptoms of dehydration, and is supposed to occur (in Lyons where the authors have made their observations) during those periods when the wind blows from the south. The authors also discuss what they call "Les inadaptés urbains." These are people living in

cities, who, whether definitely ill or not, are inevitably benefited by a change to the country. It is supposedly a constitutional weakness that is inherited. This book being essentially a review of the literature, the subject has received superficial treatment; this fault is compensated by an extensive bibliography of 28 pages.



CELL NUTRITION AND MEDICATION for Layman, Student and Practitioner. An Introductory Treatise on Phytotherapy and Biochemistry, with a More Advanced Section Dealing with these Sciences in Practice.

By Eric F. W. Powell. C. W. Daniel Co., London. 7s. 6d. net. $8 \times 5\frac{1}{2}$; 163; 1934.

This volume deals with phytotherapy, a high-toned euphemism for "yarb doctoring," and with a quaint philosophy, which is that "all the substances necessary to heal, restore and overcome diseased conditions are normally found within the organism itself; that the body is a self-curative machine, and that it will maintain its efficiency provided it has a normal supply of all those vital elements peculiar to its own substance."

This reminds us of two lines of a verse about Mary Baker G. Eddy that Reginald, the Office Boy, likes to sing while doing his laboratory chores. It is the 136th of 249 verses of an immortal patriotic song entitled "I am a One Hundred Percent American." The lines referred to are:

Disease is now laid on the shelf
And the dead man only kids himself.



IDEAL HEALTH or The Laws of Life and Health. Third Edition.

By Alexander Bryce. William Wood & Co., Baltimore. \$2.00. $7\frac{1}{4} \times 4\frac{1}{2}$; xi + 340; 1935.

The third edition of this little text on the preservation of health is very readable for the layman. Health, the author emphasizes, has no necessary relation to strength but is defined as "that condition of the body which prevents the growth of pathogenic micro-organisms, and in its simplest aspect is exemption from disease," and

on the positive side, "a healthy organism is one which can adapt itself and go on adapting itself, both in structure and function to its surroundings." The physiological effects of food, drink, work, rest, air, exercise, cleanliness, clothing, regularity and moderation, are dealt with. There is an interesting chapter on the influence of the mind on the body, and a closing chapter on eugenics.



QUARTERLY BULLETIN OF THE HEALTH ORGANISATION. *Special Number, January 1935. Biological Standardisation.*

League of Nations, Geneva. World Peace Foundation, 8 West 40th St., New York. 2s. 6d.; 6s cents. 9½ x 6½; 127; 1935 (paper).

This special number of the *Bulletin* contains the report of the permanent commission on biological standardization and several articles regarding the experiments which were made to arrive at an international standard in the preparation of certain antitoxins and sera. P. Hartley and P. White write on a proposed standard for gas gangrene and toxin (vibron septique); L. E. Walbrun and C. Reymann, for gas gangrene antitoxin (Edematiens); P. Hartley and W. Smith, for antipneumococcus serum (type I and type II); P. Hartley and M. L. Smith, for staphylococcus antitoxins. In addition there is a report of the conference held in 1932 on the standardization of sex hormones.



A CLASSIFIED BIBLIOGRAPHY ON PSYCHO-DIETETICS. *Psychological Monographs, Vol. XLVI, No. 2, Whole No. 206.*

By Martin F. Fritz. *Psychological Review Co., Princeton, N. J.* 75 cents. 9½ x 6½; 53; 1934 (paper).

This bibliography of the relationship between diet and mental phenomena consists of 669 references to articles in English appearing up to the year 1933. These are classified under the headings of pernicious anemia, pellagra, sprue, acrodynia, migraine, epilepsy, appetite, racial vigor and

temperament, endurance, intelligence and learning, mental disorders, intestinal toxemia, sense organs, allergy, sex expression, longevity, hypertension, Ménière's disease, beriberi, and general. Besides the titles brief abstracts of the articles are given. This gathering together of results emphasizes the very different conclusions to which different investigators have come.



MODERN MOTHERHOOD. *A Book of Information on Complete Maternity Care: Prenatal—Delivery—Aftercare.*

By Claude E. Heaton. Farrar and Rinehart, New York. \$2.00. 7½ x 4½; xxii + 271; 1935.

This is an excellent handbook for the woman interested in the practical physiology of prenatal and postnatal care. Three of the book's chief attributes are its clarity of presentation, its removal of much of the mysticism usually shrouding such matters, and its practicality in suggesting helpful routines.

The modernity of the book can be realized from the following quotation:

Little need be said about clothing. To read most of the absurd advice given, one would think doctors know very little about what a pregnant woman should wear. Those women who are used to high heels are not going to wear flat ones. . . .



THE CONQUEST OF SUFFERING.

By Ritchie Calder. Methuen and Co., London. 5 shillings net. 7½ x 4½; xvi + 166; 1934.

In this volume the author describes some of the more spectacular developments of medical and physiological science such as "The war against death," "The retreat from the slums," "The battle for babies," etc. The book is well written but seems to lack in places the critical judgment of the scientific man and suggests, as is indeed true, that the author is a competent journalist rather than a medical or biological scientist. There is a foreword by J. B. S. Haldane.

FOOD AND HEALTH.

By Henry C. Sherman. *The Macmillan Co., New York.* \$2.50. 7 $\frac{1}{2}$ x 5 $\frac{1}{8}$; x + 296; 1934.

This book discusses all that is most recent in nutritional knowledge. Vitamins are emphasized and their necessity for a healthful diet. The economic value of various food stuffs in relation to their calorific and vitamin content is also discussed at some length. A considerable section in the form of appendices is devoted to tables of caloric content of various foods and to illustrative meals covering three meals a day for six months. The book is intended for the layman and should contain much interesting and easily understood information for the housewife.

MYOSITES *Abscès des Muscles.*

By J. Pergola. *Masson et Cie, Paris.* 35 francs. 10 x 6 $\frac{1}{2}$; xiv + 166 + 3 plates; 1935 (paper).

An etiological, anatomical, and pathological study of myositis or abscesses of muscular tissues. Part I treats the acute types of sanguineous origin, Part II the chronic, or syphilitic, tuberculous, and sclerous types. The sclerous type is one of the most difficult to diagnose since its etiology simulates clinically that of malignant neoplasms. The book is illustrated and equipped with a bibliography.



PRÉCIS DE PHYSIQUE MÉDICALE.

By André Strobl. *Masson et Cie, Paris.* 60 francs (paper); 70 francs (cloth). 7 $\frac{1}{2}$ x 5 $\frac{1}{8}$; 723; 1935.

This handbook contains a very clear exposition of the applications of physics to physiologic problems. The first and second parts treat of energy, acoustics and optics in a complete but rather superficial manner. Greater attention is given instead to those phenomena related to light radiation, electricity and radiology. These are described in the third part of the book and the author has recorded in

great detail the results of the more recent discoveries and experiments.



LE BILAN MATÉRIEL ET L'ÉNERGÉTIQUE DES SYNTHÈSES BIOLOGIQUES. *Actualités Scientifiques et Industrielles*, 214. *Exposés de Biologie (Physiologie Cellulaire)*, I.

By Hiroshi Tamiya. *Hermann et Cie, Paris.* 10 francs. 10 x 6 $\frac{1}{2}$; 45; 1935 (paper).

Tamiya's method of analysis of the respiratory process in fungi is based on a comparison of the CO₂/O₂ ratios obtained by the combustion of the mycelium and the carbohydrate on which it was grown. The booklet is devoted to the mathematical development of this concept and to the application of the results to the data obtained by Terroine and his associates, Algeria, and the author.



DIE PHYSIOLOGISCHEN UND PHYSIKALISCHEN GRUNDLAGEN DER HAUTTHERMOMETRIE. *Mit einem Anhang über weitere physiologische Temperaturmessungen.*

By H. Pfeleiderer and K. Büttner. *Johann Ambrosius Barth, Leipzig.* 4.80 marks. 9 $\frac{1}{2}$ x 6 $\frac{1}{2}$; viii + 52; 1935 (paper).

A description of techniques and equipment for the measurement of skin temperature, which are simple and inexpensive enough for use in small laboratories, clinics, and field investigations. There is a list of firms from which the necessary apparatus may be purchased, and a bibliography.



THE CIRCULATION OF BLOOD IN AMMOCOETES. *University of California Publications in Zoology*, Volume 39, Number 16.

By J. Frank Daniel. *University of California Press, Berkeley.* 50 cents. 10 $\frac{1}{4}$ x 6 $\frac{1}{2}$; 29; 1934 (paper).

QUARTERLY BULLETIN OF THE HEALTH ORGANISATION. Volume 3, No. 4.

League of Nations, Geneva. World Peace Foundation, 8 West 40th St., New York. 2s. 6d.; 65 cents. 9 $\frac{1}{2}$ x 6 $\frac{1}{2}$; 200; 1934 (paper).

BIOCHEMISTRY

A TEXTBOOK OF BIOCHEMISTRY.

Edited by Benjamin Harrow and Carl P. Sherwin. W. B. Saunders Co., Philadelphia. \$6.00 net. 9 x 6; 797; 1935.

The thirty chapters of this excellent biochemistry reference book have been written by as many prominent American and British biochemists who are working actively in the fields they review. Although the treatment accorded to their subject matter varies greatly, most of the authors have shown a biological, rather than a medical bias in the selection of their subject matter, laying emphasis on the features that man possesses in common with the lower animals instead of on the clinical or pathological phenomena which are included in texts intended for medical students. There is also an unusual emphasis on the physico-chemical properties of important substances.

Some authors are discursive, as in the chapter on nutrition; others confine themselves to general principles, as is the case in the treatment of enzymes and of cellular physiology; and still others, such as Carl L. A. Schmidt, who writes on the physical chemistry of amino acids and proteins, devote about as much space to tables and graphs as they do to text, and stud the text with equations. In between there is every gradation in technicality. The field of biochemistry is well and capably covered by these chapters, but it would be fairer to call the volume a reference book rather than a text book, in view of this unevenness of treatment, and because the articles are discrete units rather than a planned part of a large-scale logical development of the principles of biochemistry.

Bibliographies, usually of 40 to 200 titles, follow each article. There is an author index by which these citations can be located and an excellent subject index.



PRÉCIS DE CHIMIE BIOLOGIQUE MÉDICALE.

By Paul Cristol. Masson et Cie, Paris. 70 francs (paper); 80 francs (cloth). 7½ x 5½; 638; 1935.

A handbook of biochemistry especially adapted to the needs of medical students.

It is divided into four parts. The first includes chapters on the chemical constitution of living organisms and on hydrocarbons. The second part concerns the glucides. The author first describes the synthesis due to the action of chlorophyll and then in order outlines the intermediate and final chemical transformations of the glucide molecules which are supposed to take place as a result of metabolism. In this same fashion he treats of the lipoids in the third part and of the proteins in the fourth section. It is an excellent method which is used in most textbooks of physiology but rarely in those on biochemistry. The student is thus able to interpret more intelligently both the physiologic or pathologic processes and the chemical changes. Brief accounts of the latest discoveries are also given in this book but the author has omitted the bibliography.



A HISTORY OF FOOD ADULTERATION AND ANALYSIS.

By Frederick A. Filby. George Allen and Unwin, London. 10 shillings net. 8½ x 5½; 269; 1934.

An interesting research into the history of sophistication of food, drugs and drink in England before 1820. The author, a chemist, is especially interested in the development of chemical analysis for the detection of adulteration and it is from this standpoint that he has conducted his investigation. Since in the early period that he covers it was the office of the several guilds to protect the quality and price of their products the author has accordingly subdivided his book and dedicated a chapter each to grocers, bakers, brewers, vintners, and distillers. The information that he has obtained by consulting ancient laws, treatises, etc., reveals remarkable examples of human ingenuity in perpetrating and detecting adulteration.



BIOCHEMICAL LABORATORY METHODS for Students of the Biological Sciences.

By Clarence A. Morrow. Revised and Rewritten by William M. Sandstrom. John

Wiley and Sons, New York. \$3.75 net.
9 x 5½; xv + 319; 1935.

This is the second, revised edition of an excellent laboratory manual of plant biochemistry. It was specifically planned to accompany Gortner's *Outlines of Biochemistry* but it has a far wider field of usefulness, in general physiology courses, for instance. A large proportion of the experiments are of a quantitative nature, employing such procedures as the Van Slyke procedures for protein analysis and the Munson and Walker method for sugar determinations. Very satisfactory bibliographies are appended to the directions for each experiment. There are photomicrographs of the osazones of the common sugars. There is an author index and a subject index.



HANDBUCH DER BIOLOGISCHEN ARBEITSMETHODEN. *Lieferung 440. Fermentforschung.* Containing following articles: *Die Ausführung der Abderhalden-Reaktion mittels des Eintauchrefraktometers nach Pregl-de Crinis*, and *Die quantitative Bestimmung der Abwehrfermentwirkung mittels des Interferometers*, by Paul Hirsch; *Pepsin, Trypsin, Chymo-Trypsin*, by John H. Northrop and M. Kunitz; *Ketonaldehydemutase*, by Carl Neuberg and Ernst Simon; *Emulsin*, by Karl Tauböck; *Die Methodik der Dehydrogenasen*, by Torsten Thunberg.

Urban und Schwarzenberg, Berlin. 13.50 marks. 10 x 7; 245; 1935 (paper).

Hirsch describes in the first article the use of the immersion-refractometer method devised by Pregl and de Crinis in determining the Abderhalden pregnancy reaction; in the second, methods of quantitative determination of the action of protective ferments by means of the interferometer, with especial reference to endocrine dysfunction. Northrop and Kunitz discuss the isolation and crystallization of pepsin, trypsin, and chymo-trypsin obtained from the pancreas. The other articles deal respectively with the isolation of the enzyme ketonaldehydemutase and its distribution in plants and animals; emulsin; and a history of methods used for the isolation of the dehydrogenizing enzymes.

GESCHICHTE DER PHYSIOLOGISCHEN CHEMIE.
By Fritz Lieben. Franz Deuticke, Wien.
20 marks (paper); 23 marks (cloth).
10 x 7; x + 743; 1935.

A comprehensive history of physiological chemistry. Part I, covering 96 pages, treats the subject from the earliest times through the nineteenth century with main reference to the great workers in the field—Lavoisier, Berzelius, Liebig, Arrhenius and others—and arranged in more or less chronological order. Part II carries the investigations to the present time and is arranged by topics. The book is well documented and contains a bibliography of 18 pages, printed in small type with three columns to the page, and a subject index.



ANNUAL REVIEW OF BIOCHEMISTRY. *Volume IV.*

Edited by James M. Luck. *Annual Review of Biochemistry, Stanford University P. O., Calif.* \$5.00. 8¼ x 6; vii + 639; 1935.

To the users of the earlier volumes of this valuable annual review it is only necessary to say that three topics, which have not been treated hitherto in this series, have been included: choline and related compounds, the biochemistry of malignant disease, and plant hormones. In this volume, 27 of the most actively investigated fields of biochemistry have been surveyed by competent specialists who manage to include about half of the previous year's output of papers, noting their bearing on earlier work, and giving citations.



HANDBUCH DER BIOLOGISCHEN ARBEITSMETHODEN. *Lieferung 441. Allgemeine und vergleichende Physiologie (Ergänzung zu Abt. V, Teil 2).* Containing following articles: *Die Bestimmung der Wasserstoffionenkonzentration der Gewebe bei lebenden Tieren mit Hilfe der Kapillarglaselektrode*, by Carl Voegtlin, Herbert Kahler and R. H. Fitch; *Methoden zur Bestimmung des Oxydations-Reduktionspotential*, by Leonor Michaelis;

Methoden zur Untersuchung der Wirkung von α - und β -Strahlen, by Marie Wreschner.

Urban und Schwarzenberg, Berlin. 9 marks. 10 x 7; 158; 1935 (paper).

The first article describes methods and sources of error in the determination of the pH of living animal tissues by means of the capillary glass electrode. The second paper treats methods for the determination of the oxidation-reduction potential, and the third methods for studying the mechanism of action of α and β rays.



LES PROBLÈMES DE LA RADIOGÉOLOGIE. *Actualités Scientifiques et Industrielles 201. Exposés de Géologie, I.*

By W. Vernadsky. Hermann et Cie, Paris.

15 francs. 10 x 6½; 67 + folding table; 1935 (paper).

This is a résumé of the work which has been done by the author and others on the radioactive elements since 1902 when Curie published his first work on the subject. The material was originally presented as two lectures given in 1933 at the University of Paris. A three-page bibliography and a copy of the International Table of radioactive elements are provided.



THE EFFECTS OF METHYLENE BLUE AND OTHER OXIDATION-REDUCTION INDICATORS ON EXPERIMENTAL TUMORS. *University of California Publications in Zoology, Volume 39, Number 14.*

By Matilda M. Brooks. University of California Press, Berkeley. 25 cents. 10½ x 6½; 9; 1934 (paper).



SEX

SEX AND TEMPERAMENT. *In Three Primitive Societies.*

By Margaret Mead. William Morrow and Co., New York. \$3.00. 8½ x 5½; xxii + 335; 1935.

Miss Mead's problem has been to study in three groups of primitive peoples in New Guinea (the mountain-dwelling Arapesh, the river-dwelling Mundugumor and the lake-dwelling Tchambuli) the "pattern-

ing of sex-behaviour from the standpoint of temperament, with the cultural assumption that certain temperamental attitudes are 'naturally' masculine and others naturally 'feminine.' She found that in two of the three tribes (the Arapesh and the Mundugumor) the idea that temperamental traits of the order of dominance, bravery, aggressiveness, objectivity, malleability, are inalienably associated with one sex (as opposed to the other) is entirely lacking. The Arapesh ideal is the mild responsive man married to the mild responsive woman, the Mundugumor ideal is the violent, aggressive man married to the violent, aggressive woman. In the third tribe quite a different situation exists: the woman is the dominant, impersonal, managing partner, the man the less responsible and emotionally dependent person. From these studies she concludes that we have no basis for regarding temperamental attitudes as sex-linked. In her final chapters she discusses at length the belief that has developed in civilized countries that certain human traits are linked with the opposite sex and the maladjustment that results when parents attempt to condition their offspring to the socially accepted male or female behavior. The general reader, as well as students of ethnology cannot fail to be interested in the contents of this book. The psychiatrist will do well to read it with an open mind. The volume contains an index and a glossary.



MEN AND WOMEN. *The World Journey of a Sexologist.*

By Magnus Hirschfeld. G. P. Putnam's Sons, New York. \$4.00. 8½ x 6; xix + 325 + 6 plates; 1935.

An entertaining account of a sexological lecture tour around the world by a distinguished old gentleman, who in common with many another found Germany uncomfortable in its present régime, after having spent a lifetime adding to its scientific fame. Dr. Hirschfeld is a shrewd and wise observer of human behavior, with a broad and tolerant philosophical and historical background. The book rambles somewhat verbosely along in a pleasant

way over a great variety of aspects of the human scene, some of which are passing curious. We are told of the location of brothels near the temples at places of pilgrimage in Japan, to be "eagerly visited by the pilgrims once they have set down their offerings and made their prayers;" of the close relationship between ancestor worship and worship of the phallus; of the great stone elephants at the Ming tombs whereon pregnant women fling small stones—if they stick it will be a boy, if they fall off only a girl; of the ghastly ravages of tuberculosis in China; of the Chinese Jews, there since long before the birth of Christ; of homosexual silk-worm moths; of the quaint Javanese custom of jingling coins at confinement so to lure the baby out more quickly; of the inbreeding in Egypt that has gone on for more than 5000 years.

Dr. A. A. Brill contributes a foreword; the book is sparingly illustrated with photographs, and is well indexed. It will be an interesting and worthy addition to any library of human biology.



DIE FOLGEN DER ENTMANNUNG ERWACHSENER. *An der Hand der Kriegserfahrungen dargestellt.* *Arbeit und Gesundheit*, Heft 24.

By Johannes Lange. Georg Thieme, Leipzig. 5 marks. $9\frac{1}{2}$ x $6\frac{1}{2}$; 178; 1934 (paper).

This study is based on 179 males who were totally castrated and 68 partially castrated as results of wounds received during the war, and 63 on whom the operation was performed on account of tuberculous conditions. At the time of study they ranged in age from 35 to 55 years, and the duration of the condition ranged from 11 to 20 years, with a few tuberculous cases under 10 years. A high proportion were found to have undergone physical changes—changes in body proportions, reduced weight and a feminine distribution and limitation of body hair. There was also a high correlation between emasculation and nervous disorders such as hysteria and neurasthenia, but a low correlation in respect to epilepsy and manic-depressive or schizophrenic manifestations. Nearly one half of the book is devoted to detailed case histories.

THE CHOICE OF A MATE.

By Anthony M. Ludovici. *John Lane, London.* 15 shillings net. $8\frac{1}{2}$ x $5\frac{1}{2}$; xxi + 510; 1935.

This 500 page volume is obviously for the mature reader. The author's aim has been to supply authoritative information and guidance in the choice of a mate. To do this he has amassed a vast amount of material which he groups under three general headings. In Part I one finds the following subjects discussed: Obstacles in the way of a sound choice, consanguinity, beauty and ugliness, beauty and health. Part II is devoted to physiognomy, human points and morphology, disease and character, neuroses, positive and negative people, type and character, the female leg and the influence of dress on morphology and temperament, etc. Part III is in general a summing up of what is desirable in a mate, both from the male and the female points of view. The volume is extensively documented and is indexed. Norman Haire contributes an introduction.



FEMALE SEX PERVERSION. *The Sexually Aberrated Woman As She Is.*

By Maurice Chidekel. *Eugenics Publishing Co., New York.* \$6.00. $9\frac{1}{2}$ x $6\frac{1}{2}$; xviii + 331; 1935.

This is a psychiatric review, couched in non-technical language, of the sexual perversions of the human female. Such subjects as homosexuality, sadism, masochism, exhibitionism, and prostitution, along with others, are discussed in the book. Lay readers may find this book a pretty strong draught. The volume has a certain frankness of attitude about it which will discourage the lascivious minded. The drawings, although interesting, do not seem to be in keeping with the rest of the text.



SEXING DAY-OLD CHICKS. *A Treatise on Sex Detection in Pure- and Cross-Bred Chicks.*

By W. P. Blount. *Poultry World, London.* 2s. 6d. net. $7\frac{1}{2}$ x $4\frac{1}{2}$; 54; 1934.

This little book sets forth clearly and concisely a method developed over a number

of years by the Japanese in sexing baby chicks. The method is simple, requires no unusual apparatus and can be easily learned by the layman who is willing to sacrifice in the course of his training a certain number of day-old chicks. Speed and accuracy are highly important. Experts, and at present these are mostly Japanese, can sex as many as 600 or even 800 chicks in an hour with a success of 90-95 per cent. Poultry keepers will find this book of great practical value.



BIOMETRY

WAHRSCHEINLICHKEITSLEHRE. *Eine Untersuchung über die logischen und mathematischen Grundlagen der Wahrscheinlichkeitsrechnung.*

By Hans Reichenbach. A. W. Sijthoff's Uitgeverij, Leiden. 11.50 H. fl. (paper); 13.50 H. fl. (cloth). 9½ x 6½; ix + 452; 1935.

Professor Reichenbach, whose *La Philosophie Scientifique* was reviewed in Volume 9, page 258, takes as the epigraph of the present work the following sentence from a letter of Leibniz to Malebranche: "Les mathématiciens ont autant besoin d'être philosophes que les philosophes d'être mathématiciens." His own approach to the difficult problem of the foundations of the theory of probability is along the twin paths of philosophy and mathematics. In the process light is thrown on the significance of *a priori* probabilities and a generalization of symbolic logic is developed in which the two values, truth and falsity, are replaced by a continuous scale of truth values. This makes possible the solution of the problem of induction which since the days of Hume has stood as an unsolved riddle in the path of epistemology. Induction does not give us certainty but it is the only systematic procedure for practical action that we know of.

A blind man, who has lost his way in the mountains, discovers a path with his staff. He knows not whither the path goes, not even that it may not lead to a precipice down which he will plunge. And yet he will follow the path, feeling his way step by step with his staff. For if there is any possibility of his escaping from the wilderness it is by feeling his way along this path. We stand like blind men before the

future but we feel our way along a path and we know that if we are to find any route through the future it will be along this path.



PRACTICAL APPLICATIONS OF THE PUNCHED CARD METHOD IN COLLEGES AND UNIVERSITIES

Edited by G. W. Basbns. Columbia University Press, New York. \$4.50. 10 x 7; xxii + 442; 1935.

During the United States census of 1880 it became evident that with the rapid increase in population the methods of hand tabulation of the census data then in use would soon break down through sheer unwieldiness. John S. Billings, the distinguished sanitarian and founder of the *Surgeon General's Catalogue and Index Medicus*, who was in charge of the collection of vital statistics, suggested to a young engineer in his office, Herman Hollerith, that "There ought to be some mechanical way of doing this job, something on the principle of the Jacquard loom, perhaps, whereby holes on a card regulate the pattern to be woven." Hollerith took up the suggestion and devised the electrical method of tabulation by means of punched cards which is now so widely used by both statistical and accounting offices in many parts of the world.

This book points out specific methods for the utilization of punched card equipment by colleges and universities, both in the administrative tabulations of the registrar's and business offices and in research in various fields done by the statistical method. Among the fields which are specially treated are psychology and educational research, medical research and hospital statistics, legal research, agricultural research (including genetics), anthropology, astronomy, economics, literature (concordances), and social sciences. In two final chapters Professor H. C. Carver describes the use of the automatic multiplying punch and Professor A. E. Brandt that of the progressive digit method in the computation of moments, correlations, analysis of variance and covariance, and curve fitting by least squares. There is an adequate index.

PSYCHOLOGY AND BEHAVIOR

STUDIES IN EXPRESSIVE MOVEMENT.

By Gordon W. Allport and Philip E. Vernon. With a chapter on *Matching Sketches of Personality with Scripts*, by Edwin Powers. The Macmillan Co., New York. \$3.00. 7½ x 5½; xiii + 269. 1933.

As the authors point out in their introduction,

Investigations of personality may be focused upon any one of three different levels of phenomena. The first is the level of traits, interests, attitudes, or sentiments considered as composing an "inner" personality; the second is the level of behavior and expression; the third is the level of impression, the perception and interpretation of behavior by another. Since a discovery on one of these levels establishes a presumption that the phenomenon in question has some counterpart on the other levels, a problem which is elusive on one plane may often be more expediently attacked on another. This is the motive and the plan behind the present study. Instead of approaching the difficult problem of consistency or organization in personality through a study of "inner" dispositions—which, of course, can only be known indirectly through tests and scales—we have chosen to refer the problem to the level of expressive movement and there to examine it in a more direct fashion.

The experiments on which the book is based deal with such behavioral characters as speed of reading, counting, walking, drawing and writing, estimation of known sizes, distances, angles and weights, point and grip pressure in drawing and writing, muscular tension, and ratings on voice intensity, speech fluency, amount of movement during conversation and during idleness, freedom and smoothness of movement, tempo of activity, neatness, and forcefulness of personality. These characters, it was found, are neither wholly independent nor completely correlated but fall into several groups, the members of each of which are rather highly correlated with one another but show only small correlations with members of other groups. The second part of the book deals with handwriting and personality. In several experiments under controlled conditions graphological analyses, while by no means perfect in accuracy, showed somewhat greater correspondence with analyses by other methods than was to be expected from chance alone.

From our results it appears that a man's gesture and handwriting both reflect an essentially stable and constant individual style. His expressive activities seem not to be dissociated and unrelated to one another, but rather to be organized and well-patterned. Furthermore, the evidence indicates that there is congruence between expressive movement and the attitudes, traits, values, and other dispositions of the "inner" personality. Although the question of organization of the personality as a whole is beyond the scope of this volume, it is clear that the foundations for an adequate solution of this important problem cannot be supplied by the anarchic doctrine of specificity but only by the positive and constructive theories of consistency.

There are a bibliography of 206 titles and author and subject indices.



A HANDBOOK OF SOCIAL PSYCHOLOGY.

By W. C. Allee, Gordon W. Allport, Friedrich Alverdes, R. E. Buchanan, Fred-eric E. Clements, J. F. Dashiell, Erwin A. Esper, Herbert Friedmann, Edwin Deeks Harvey, Melville J. Herskovits, Catharine C. Miles, Walter R. Miles, Gardner Murphy, Lois B. Murphy, O. E. Plath, Thorleif Schjelderup-Ebbe, Victor E. Shelford, Warren S. Thompson, W. D. Wallis, F. L. Wells, Raymond R. Willoughby, Clark Wissler, Ada W. Yerkes, Robert M. Yerkes. Edited by Carl Murchison. Clark University Press, Worcester, Mass. \$6.00. 9 x 6; xii + 1195; 1935.

In the preface to this volume the editor remarks: "It is with something akin to despair that one contemplates the piffling, trivial, superficial, damnably unimportant topics that some social scientists investigate with agony and sweat. And at the end of all these centuries, no one knows what is wrong with the world or what is likely to happen to the world." These are harsh words, yet, especially after reading this symposium, one must agree with him. For example, the object of this book is to illustrate the methods and results of investigating human social activities. However, with but few exceptions most of the articles deal either with non-human social behavior or with "abnormal" human behavior and contribute to the study of the main problem very indirectly if at all. Part I contains articles on the population behavior of bacteria, social origin and processes among

plants, growth factors in human populations. The second part contains articles on insect and bird societies and mammalian packs and herds. The third part treats of the social history of the Negro, red man, white man and yellow man. The first of these papers on the Negro by M. J. Herskovits deserves special mention. The fourth part deals with language, magic and cognate phenomena, and material culture. The articles on magic by R. R. Willoughby and on material culture by C. C. Wissler are good though somewhat superficial. In the fifth part, on the analysis of some correlates of social phenomena, there is a fine article by G. W. Allport on Attitudes. However, he mentions neither Sumner's *Mores* nor Pareto's *Residues*. The sixth part deals with the social behavior of birds, infra-human primates, and school children. Here is an excellent paper by J. F. Dashiell on "Experimental studies of the influence of social situations on the behavior of individual human adults."

If one leaves out any consideration of the main purpose of this book, it can be said that almost every one of the papers included is well written, interesting and worth reading.



THE PSYCHO-BIOLOGY OF LANGUAGE. *An Introduction to Dynamic Philology.*

By George K. Zipf. Houghton Mifflin Co., Boston. \$3.50. 8½ x 5½; xi + 336; 1935.

A highly interesting book. Unfortunately an adequate conception of its contents can not be given in a limited space. The investigator has by the application of statistical principles studied speech as a natural phenomenon—as a "peculiar form of behavior of a very unusual extant species." He views the stream of speech as a series of communicative gestures. Among the important findings are to be noted the following: the length of a word is closely related to the frequency of its usage—the greater the frequency, the shorter the word; the more complex any speech element is phonetically, the less frequently it occurs; the frequency distribution of words is of a

high degree of orderliness, i.e., the most frequent word in any extensive sample of connected English will occur on the average once in approximately every 10 words, the second most frequent word once in every 20 words, the tenth most frequent word once in every 100 words, the n th most frequent word in every 10 n words; if the number of different words occurring once in a given sample is taken as x , the number of different words occurring twice, three times, or n times is according to the inverse square, valid for well over 95 per cent of all the different words used in the sample. His results point quite conclusively to the "existence of a fundamental condition of equilibrium between the form and function of speech-habits, or speech-patterns, in any language." Since words are selected according to their meanings and according to the ideas and feelings which one wishes to convey, Zipf has devoted his research also to the problems of meaning, emotion and mental behavior in general in the light of his results in the stream of speech.

The various chapter headings are: The Form and Behavior of Words; The Form and Behavior of Phonemes; Accent within the Word; The Sentence: Positional and Inflectional Languages; The Stream of Speech and its Relation to the Totality of Behavior. The volume contains tables of statistical data, a section on notes and references, and is indexed.



GESTALT PSYCHOLOGY. *A Survey of Facts and Principles.*

By George W. Hartmann. The Ronald Press Co., New York. \$3.50. 8 x 5½; xiii + 325; 1935.

Since the days of the Greeks the problem of the whole and its parts has divided scientists into two camps. Democritus and his followers fixed their attention on the parts, whereas to Aristotle organization was the significant fact. With Dalton the atomic viewpoint triumphed in chemistry and physics and during the greater part of the nineteenth century dominated most of the sciences. With the twentieth century a reaction has taken

place, so that, as Whitehead has said, physics is becoming the study of organisms.

Psychology too has experienced these changes of fashion. Through most of the nineteenth century the associationists, who regarded the mind as a collection of atomic sensations, were the dominant party but towards the end of the century Ward, Stout, von Ehrenfels and Meinong emphasized the organized character of thought. It was not, however, until 1912 that the Gestalt school of psychologists, which has developed the concept of the organization of thought in a more radical way, had its origin in Wertheimer's experiments on apparent movement.

In this book Professor Hartmann aims "to give a sympathetic picture of the Gestalt system from the standpoint of a non-configurationist, although I must confess that an examination of the evidence has left me more favorably disposed toward the theory than I had originally anticipated." He presents the historical background of the doctrine; its physical, physiological and philosophical foundations; the experimental work done by the school, which he feels will prove its most permanent contribution; its practical applications in mental pathology, industry and education; and a résumé of criticisms of Gestalt theory by other schools. Bibliographic footnotes, brief biographies of the more important Gestaltists, a chronology, a glossary and an index are also included.



WISH-HUNTING IN THE UNCONSCIOUS. *An Analysis of Psychoanalysis.*

By Milton Harrington. *The Macmillan Co., New York.* \$2.50. 7½ x 5½; 189; 1934.

Harrington's attack on the principles and practice of psychoanalysis is lively, merciless, and yet fair. The title of his book neatly indicates his chief indictment of Freud's method; it is a process by which the psychoanalyst trains the patient to give him any information he wishes to find, and the technique of interpretation is so unfettered by the rules of logic, or

indeed by any other rules, that the analyst can reach any interpretation he really wishes to find. In short, it is a species of faith healing with more than a few analogies with the technique of the old camp-meeting type of revivalist. The first 67 pages are mostly quotations, *in extenso*, of some of the more far-fetched of Freud's dream and symptom interpretations; the next 63 pages are in the best tradition of controversial writing, but the final 43 pages, in which Harrington tries to develop an alternative theory, are pretty disappointing by contrast. Perhaps, in the second volume he promises, Harrington really can explain how he can start with the present-day knowledge of anatomy and physiology and build up a mechanistic system of psychology that will explain the kind of phenomena that Freud is interested in. Skilful as Harrington is as a controversial writer, we suspect he will find that his position is easier to attack than it is to defend.



THE INDIVIDUAL CRIMINAL. *Studies in the Psychogenetics of Crime.*

By Ben Karpman. *Nervous and Mental Disease Publishing Co., Washington.* \$4.50. 8½ x 5½; x + 317 + folding chart; 1935.

The author herein gives an interpretation of the material which he has already published under the heading *Case Studies in the Psychopathology of Crime*, 1933, (noticed in this REVIEW, Volume 8). He includes the life histories in the present volume so that it is unnecessary for the reader to refer to the earlier work. In each case study (there are five altogether) there is given an interpretation of the psychogenetics of the case, a diagnosis, a summary, conclusions, and a discussion of the psychobiology of the individual. In some of the case studies there is an additional section on crime mechanics. Following the studies there is a section on Psychotherapy: Preliminary to the psychotherapy of criminals. The volume contains a chart exhibiting the amnesic attacks of patient five, a general index and an index to criminal jargon.

EYE-MOVEMENT DURING VISUAL IMAGERY.
Comparative Psychology Monographs, Vol. 11,
No. 3, Serial No. 53.

By Edith Totten. Johns Hopkins Press,
Baltimore. 75 cents. 10 x 6 $\frac{1}{2}$; 46;
1935 (paper).

Of 105 photographs of the eyes of seven subjects while engaged in visual imagery of assigned objects, 75 showed eye-movements such as would be required in the perception of those objects. Twenty-one were doubtful and nine negative. The author suggests that in those registering no eye-movements some other muscular mechanism may have been substituted, or the muscular change in the eye may have been so slight as not to produce a change in the position of the eye-ball great enough to be caught by the camera. The technique used by the author is described and 56 of the photographs are reproduced. There is a bibliography.



HISTOIRE NATURELLE DE LA CONNAISSANCE
CHEZ LE SINGE INFÉRIEUR. *Le Concret.*
Actualités Scientifiques et Industrielles 215.
Exposés de Psychologie Animale, I.

By Louis Verlaine. Hermann et Cie,
Paris. 12 francs. 10 x 6 $\frac{1}{2}$; 55; 1935
(paper).

This is the first of three studies on the perceptive faculties, concrete and abstract, of Coco, a young *Macacus rhesus*, aged two and a half years. The experiments described in this number include differentiation between squares of paper of different colors, and strips of paper of different lengths or widths, and of various geometrical forms. Further experiments and the conclusions will be given in the other numbers of the series.



THE BEHAVIOR OF SOME YOUNG RAPTORIAL
BIRDS. *University of California Publications*
in Zoology, Volume 40, Number 8.

By E. Lowell Sumner, Jr. University of
California Press, Berkeley. 35 cents. 10 $\frac{1}{2}$
x 6 $\frac{1}{2}$; 31; 1934 (paper).

DE OMNIBUS REBUS ET QUIBUSDEM ALIIS

LOGIK DER FORSCHUNG. *Zur Erkenntnis-*
theorie der modernen Naturwissenschaft.

By Karl Popper. Julius Springer, Berlin.
13.50 marks. 8 $\frac{1}{2}$ x 5 $\frac{1}{2}$; vi + 248; 1935
(paper).

It is commonly said that, while such disciplines as mathematics proceed deductively from general propositions to their consequences, the empirical sciences proceed inductively from particular to general propositions. But the logical validity of induction is itself not so clear as to make it a safe foundation for the sciences. If Tom has red hair, and Dick has red hair, and Harry has red hair, am I therefore justified in asserting that all men have red hair? Obviously not. If I multiply my observations and find only red haired men, nevertheless I cannot exclude the possibility that some day I shall discover a black haired man. Popper therefore regards the logic of the empirical sciences as a strictly deductive process. A hypothesis is formed and its consequences are derived deductively. If these consequences are contradicted by experience the hypothesis goes into the waste basket, but if the consequences are not contradicted this does not mean that the hypothesis is proved. It remains in the limbo of provisional hypotheses, subject always to the possibility that some day one of its consequences and therefore the hypothesis itself will be disproved.

The old ideal of science, absolutely certain knowledge, has proved itself an idol. The demand of scientific objectivity leads to the conclusion that every scientific proposition is *provisional*. It can indeed be verified—but every verification is relative to other, likewise provisionally established propositions. Only in our subjective convictions, in our faith can we be "absolutely certain."

With the idol of certainty, even of gradually evolving certainty, falls one of the most difficult obstacles in the path of research; an obstacle not only to boldness in the formulation of a question but often to the rigor and honesty of verification. The desire to maintain one's point betrays a misconception: not the possession of knowledge, of irrefutable truths, constitutes the man of science, but the disinterested, incessant search for truth.

CAPITALISM Carries On.

By *Walter B. Pitkin*. *Whittlesey House, McGraw-Hill Book Co., New York.* \$1.75. 7 $\frac{1}{8}$ x 5; xi + 282; 1935.

Mr. Pitkin's thesis is that "Capitalism thrives only where natural resources are abundant, and buyers stand ready to snap up offerings. It can be sustained elsewhere only by an enormously inflated and artificial foreign trade." If the idleness problem can be solved and the nation kept out of war he believes that the old American system can continue. But some form of controlled production must be adopted. An uncontrolled capitalism results in "anarchy, madness and ruin." He has grave doubts, however, as to whether we are able to give capitalism a fair trial. This demands that the "entire middle class must once more be marshalled for research exploration, discovery, invention and creative planning." The highest order of technological skill must be brought into political and social authority. Mr. Pitkin dedicates his book to "The Middle Class on whose survival and prosperity all civilization depends." The volume is without index.

**NEW PATHWAYS IN SCIENCE.**

By *Sir Arthur Eddington*. *The Macmillan Co., New York.* \$3.00. 8 $\frac{1}{2}$ x 5 $\frac{1}{8}$; x + 333; 1935.

In his brilliant and inimitable way Sir Arthur Eddington discusses the more recent advances in the physical sciences. The

subject matter of this volume is loosely woven together and includes chapters on the constitution of the atoms, determinism, indeterminacy and quantum theory, the expanding universe, etc. Constantly throughout the book there are expressions of the author's well-known philosophical principles which he summarizes in a final chapter entitled Epilogue. In another chapter he replies to the criticisms of Professor W. T. Stace, C. E. M. Joad, Sir Herbert Samuel and Bertrand Russell. The exposition in general is very clear and the ponderosity of the subject has been successfully lightened by timely and witty digressions. More than a good popular scientific treatise, this is to be regarded as an outstanding example of fine literary style.

**SCIENCE AND THE PUBLIC MIND.**

By *Benjamin C. Gruenberg*. *McGraw-Hill Book Co., New York.* \$2.00. 8 x 5 $\frac{1}{2}$; xiii + 196; 1935.

Says Doctor Gruenberg in the preface, "The book represents the interaction of many minds called upon to think aloud on various aspects of the relationships between that vague entity called 'science' and that perhaps even more vague something known as the 'public.'" The relation of scientific knowledge to the general layman is quite thoroughly developed in the book and the final chapter contains a detailed list of recommendations for making the public more science minded.



THE COST OF BIOLOGICAL BOOKS IN 1935

By JOHN R. MINER

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WHEN the QUARTERLY REVIEW OF BIOLOGY began publication in 1926 the custom was inaugurated of reporting at the end of each volume on the cost of the books which had been reviewed in its columns during the year. The present paper, therefore, marks a decen-

nium of these reports on the cost of biological books. The prices of foreign books have been converted into dollars on the basis of the exchange at the time the books were received.

The total number of pages reviewed in 1935 is 143,199, an increase of 15.6 per cent over 1934 and of 73.4 per cent over 1926, the year in which these tabulations began.

Table 2 shows the price trends of books published in various countries from 1926 to 1935 and the absolute and relative changes in price from 1934 to 1935 and from 1926 to 1935. The average price per page of all the books reviewed in 1935 has changed but little, being 1.032 cents, a decrease of 0.4 per cent from 1934 and of 5.9 per cent from 1926. Books produced by commercial publishing houses in the United States have decreased 3.2 per cent in price from 1934 to 1935 and 19.6 per

TABLE 1

Prices of Biological Books, 1935

ORIGIN	TOTAL PAGES	TOTAL COST	PRICE PER PAGE
			<i>cents</i>
Germany	10,049	\$205.02	2.04
British-American	13,253	203.10	1.53
Other countries	8,673	104.47	1.20
United States	80,255	722.45	0.90
France	13,229	114.36	0.86
Great Britain	14,540	122.55	0.84
British Government	605	3.00	0.50
U. S. Government	2,595	2.95	0.11

TABLE 2

Comparison of the Prices of Biological Books from 1926 to 1935

ORIGIN	AVERAGE PRICE PER PAGE										CHANGE + OR - FROM 1934 TO 1935		CHANGE + OR - FROM 1926 TO 1935	
	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	Absolute	Relative	Absolute	Relative
	<i>cents</i>	<i>cents</i>	<i>cents</i>	<i>cents</i>	<i>cents</i>	<i>cents</i>	<i>cents</i>	<i>cents</i>	<i>cents</i>	<i>cents</i>	<i>cents</i>	<i>per cent</i>	<i>cents</i>	<i>per cent</i>
British-American	1.55	1.39	1.46	1.90	1.91	2.27	1.48	1.29	1.45	1.53	+0.08	+5.5	-0.02	-1.3
Other countries	1.51	0.78	1.13*	1.68	0.97	1.53	1.02	0.85	0.86	1.20	+0.34	+39.5	-0.31	-20.5
Great Britain	1.28	1.14	1.09	1.29	1.13	1.19	0.89	0.66	0.96	0.84	-0.12	-12.5	-0.44	-34.4
United States	1.12	1.09	1.14	1.14	1.09	1.05	1.00	1.02	0.93	0.90	-0.03	-3.2	-0.22	-19.6
Germany	1.09	1.20	1.48	1.65	1.82	1.75	1.60	1.43	1.89	2.04	+0.15	+7.9	+0.95	+87.2
British Government	—	0.96	1.26	0.39	1.19	1.03	1.45	1.39	0.89	0.50	-0.39	-43.8	-0.46†	-47.9†
France	0.35	0.36	0.45	0.47	0.47	0.69	0.60	0.74	1.00	0.86	-0.14	-14.0	+0.51	+145.7
U. S. Government	0.31	0.24	0.21	0.23	0.30	0.28	0.36	0.17	0.18	0.11	-0.07	-38.9	-0.20	-64.5

* With two special treatises omitted as explained in Vol. 3, p. 601.

† Change from 1927 to 1935.

cent from 1926 to 1935. Books published by the United States Government are not only as usual the least expensive of any of the categories but have actually decreased 38.9 per cent in price since 1934 and 64.5 per cent since 1926.

As to the foreign biological books, those produced and marketed in Great Britain—both government and commercial—and France have decreased in price, expressed in terms of dollars, from 1934 to 1935, while British-American and German books, as well as those produced in countries not separately tabulated, have increased. From 1926 to 1935 prices of foreign books—except for French and German—have decreased. The prices of French books have more than doubled, but their prices in 1926 were so low that the present price is slightly lower than that of commercially published books of American origin. The fear expressed in the first of these reports that “the French publishers will over-compensate in this matter, as the Germans are alleged to have done when their currency became stabilized, and put their prices as much

too high as they have been too low in 1926” has, happily, not been substantiated.

German books, on the other hand, are now more than twice as expensive per page as American, French or British. As has been noted in previous reports, the high prices of German scientific books and periodicals have worked great hardship to both libraries and individual scientists. It is, however, reported in *Science* for October 4, 1935 (Vol. 82, p. 327) that a 25 per cent reduction in export price on German books, periodicals and continuations became effective beginning September 9, 1935. This is too late to be reflected in the present report but we hope that next year's report will show the reduction.

The reader should bear in mind that these reports are based on small samples of books in general and, for some countries, on small samples of the biological books published. He should therefore be cautious in applying conclusions drawn from this material to the general domain of book prices.



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